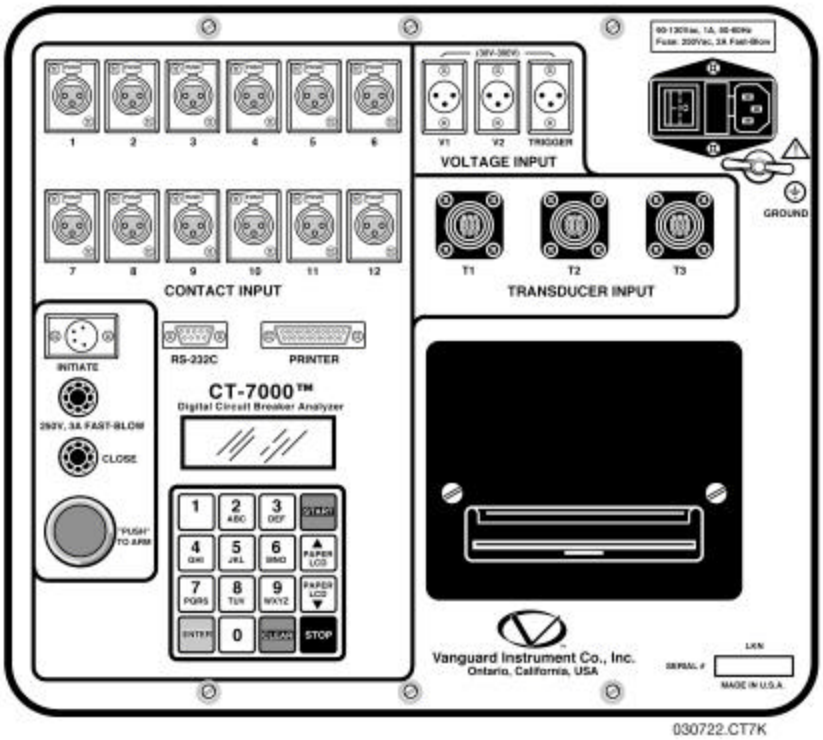
OPERATING INSTRUCTIONS
for the
CT-7000

Digital Circuit Breaker Analyzer



030722.CT7K

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October 2003
Rev 3

SAFETY WARNINGS AND CAUTIONS

Only trained operators shall use the device. All circuit breakers under test shall be **off line and fully isolated.**

DO NOT SERVICE OR TEST ALONE

Do not perform test procedures or service unless another person is also present who is capable of rendering aid and resuscitation.

DO NOT MODIFY TEST EQUIPMENT

Due to the added risk of introducing additional or unknown hazards, do not install substitute parts or perform any unauthorized modifications to any CT-7000 test unit. To ensure that all designed safety features are maintained, it is recommended that repairs be performed only by Vanguard Instruments Company's factory personnel or by an authorized repair and service center. Unauthorized modifications can cause serious safety hazards and will nullify the manufacturer's warranty.

FOLLOW EXACT OPERATING PROCEDURES

Any deviation from the procedures described in the operator's manual may create one or more safety hazards, damage the CT-7000, the test circuit breaker or cause errors in the test results. Vanguard Instruments Company, Incorporated assumes no liability for unsafe or improper use of the CT-7000.

WARRANTY

The CT-7000's warranty is only valid to the original purchaser to be free from defects in material and workmanship for a period of one year. The warranty does not apply to normal wear or damage from misuse, abuse, improper storage, installation, accident, unauthorized repair or alterations.

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1.0 Introduction

The CT-7000 is a microprocessor-based, digital time travel, circuit breaker analyzer. The CT-7000 can fully analyze a utility circuit breaker's performance by measuring: the contact time, stroke, velocity, over-travel, bounce-back and contact wipe.

The contact motion analysis includes: Open, Close, Open-Close, Close-Open and Open-Close-Open operations. A timing window is selectable between one second, ten second and twenty second periods. The ten and twenty second windows allow timing of long events such as circuit switcher contacts.

The CT-7000 is available with the following configurations:

CT-7000-3:

- Three Contact-Input channels
- Three Digital Travel Transducer Input channels
- One Analog Voltage Monitor Input channel
- One Digital Voltage Monitor Input channel
- One Trip/Close Current Monitor channel

CT-7000-6:

- Six Contact-Input channels
- Three Digital Travel Transducer Input channels
- One Analog Voltage Monitor Input channel
- One Digital Voltage Monitor Input channel
- One Trip/Close Current Monitor channel

CT-7000-12:

- Twelve Contact-Input channels
- Three Digital Travel Transducer Input channels
- One Analog Voltage Monitor Input channel
- One Digital Voltage Monitor Input channel
- One Trip/Close Current Monitor channel

There are two different modes of operation for the CT-7000 which are Stand Alone Mode and Computer Control Mode. The manual will focus on the Stand Alone Mode. The Computer Control Mode is covered under the CT-6500/7000/7500/DIGITMR PC software manual.

2.0 CT-7000 Description

The CT-7000 applies a test voltage of 35 Vdc to each of the contact channels thus allowing an analog to digital converter (A/D) to determine if a close, an open or an insertion resistor was the state of contact. The CT-7000 records into the memory 10,000 readings from the A/Ds and the transducer position counters. The contact time, circuit breaker stroke and velocity is then derived from the data that was stored in the memory.

The CT-7000 uses an up-down counter to sense the breaker's transducer reading. The CT-7000 travel transducer employs optical encoders to send quadrature signals to the CT-7000's counters. With the use of digital transducers and counters, the need to set up or calibrate the transducers is eliminated.

A built-in, initiate circuit allows the user to operate the circuit breakers. Since the solid-state circuit is controlled by a microprocessor, the CT-7000 can perform multiple contact operations with ease. The initiate circuit is fuse protected for trip and close operations. The user is required to hold the "ARM" switch during a test to complete the initiate circuit as a safety feature.

The CT-7000 can also store up to 100 breaker timing test records and 99 breaker test-plans into the FLASH EEPROM. Stored timing records can be recalled, printed or transferred to a personal computer. Using the breaker test plan with a timing test, the users do not have to set the velocity calculating points. The test report will also print “PASS” and “FAIL” results.

2.1 Contact Timing Channels

A breaker's interruption of contacts is timed with the dry-contact input channels. Each channel can detect the main contacts and the insertion resistor contact times in milliseconds and cycles.

NOTE

The CT-7000 can detect insertion resistors ranging from 10 to 7,000 Ohms. Resistances over 7,000 Ohms are detected as an open contact.

2.2 Analog Voltage Monitoring Channel

One analog voltage, input channel, “V1” is dedicated to monitoring the breaker's DC power supply or coil voltages from 0 to 255 Vdc or peak Vac.

NOTE

Input voltage ranges from 0 to 300 Vdc or peak Vac. Reading ranges from 0 to 255 Vdc.

2.3 Digital Voltage Monitoring Channel

One digital voltage, input channel, “V2” monitors the status voltage as “ON” or “OFF.” Voltages from 30 to 255 Vdc is considered as “ON” status. Voltages less than 30 Vdc is considered as “OFF” status.

2.4 Trip/Close Current Monitoring

A built-in, hall-effect, current sensor records the trip and close coil current levels and duration. The coil current waveform can be graphically plotted onto a printout. The current reading is also printed in the tabulated report.

2.5 Travel Transducer Input Channels

Each CT-7000 has three digital transducer, input channels. The CT-7000 will interface with a linear, a rotary and other special transducers developed by Vanguard Instruments Company. Please refer to Appendix I for more details.

2.6 Breaker Initiate Capability

A built-in, solid-state, initiate device allows the user to operate a breaker from the CT-7000. Operational modes include: Open, Close, Open-Close, Close-Open and Open-Close-Open. The multiple operations of: Open-Close, Close-Open and Open-Close-Open can be initiated with a programmable delay time or by sensing the breaker's contact state.

The solid-state switching implemented in the initiate circuitry allows the CT-7000 to switch a breaker's AC or DC control circuit. Two 5 Ampere, fast-blow fuses protect each trip and close circuits. An interlock, “ARM” switch also protects the initiate circuit.

2.7 Built-in Thermal Printer

The breaker's contact analysis results can be outputted in both tabular and graphical formats by a built-in, 4.5 inch wide, thermal printer. Refer to paragraph 7.4 for ordering thermal paper.

2.8 Computer Interface Capabilities

A built-in, RS-232C port permits the CT-7000 to be interfaced with an IBM-compatible

personal computer. A Windows-based Breaker Analysis Software is supplied with each CT-7000. The software is compatible with Windows 95, 98, Me, 2000, NT and XP. The software allows the user to:

- Remotely time circuit breakers from a personal computer.
- Retrieve timing shots stored in the CT-7000.
- Down-loading circuit-breaker test plans to CT-7000.
- Recall timing shots from a hard drive for reanalysis at an office PC.

2.9 Timing Shots Storage Capabilities

The CT-7000 uses Electrically Erasable Programmable Read-Only-Memory (EEPROM) to store timing-shot data. Unlike other media, EEPROMs are immune to temperature, shock and humidity. Stored shots can be recalled to reanalyze the test data, to reprint test reports or to transfer data to a personal computer for record keeping. Up to 100 timing shots can be stored in the EEPROMs. The number of shots stored in the EEPROMs may vary depending upon the size of the shot records.

2.10 Breaker Test Plan Storage Abilities

Up to 99 breaker's test plan can be stored in the CT-7000. Test plans comprise breaker specifications (i.e., stroke, velocity, contact time). By recalling and using a test plan, operators can immediately test breakers and view a pass/fail report (made by comparing test performance with specifications in the test plan.

A breaker test plan can be created by using the Breaker Analysis Software (supplied with each CT-7000). Test plan is then loaded into the CT-7000 via the RS-232C serial port.

2.11 Diagnostic Capabilities

The CT-7000 is designed with self diagnostic capability to check the integrity of the electronics. Self testing of the contact cable hook-up and transducers permits the user to examine the CT-7000's components whenever verification is required.

2.12 CT-7000 Display and Control Switches

An alphanumeric keypad enables the user to operate the CT-7000 and to enter the breaker's nameplate data such as: the substation name, breaker model and other descriptions. A 4-line by 20-character LCD readout displays user messages and menus. The LCD is backlit to allow messages can be viewed in low light conditions.

3.0 Test Result Tabulation

3.1 Electrical Measurement Results

Under the Time Travel Mode, each CT-7000 contact channel provides the following test results:

- Contact Close time
- Contact Open time
- Insertion Resistor Contact Open and Close times
- Contact Bounce time
- Resistor On time
- Contact Spread time

NOTE

The CT-7000 can detect insertion resistors ranging from 10 to 7,000 Ohms. Resistances over 7,000 Ohms are detected as an open contact.

3.2 Mechanical Measurement Results

Under the Time Travel Mode the digital, transducer channel provides the following test results:

- Breaker stroke
- Over travel
- Bounce back
- Contact wipe
- Contact velocity

Breaker contact speed calculations are based upon a contact's travel distance over a period of time, which is defined by the manufacturer's specifications.

A CT-7000 not only calculates simple distance over-time speeds, but can also support other formulas. An example is the Siemens SPS2 breaker calculation formula:

$$V=12.2 \times a/b$$

The formula and analysis point can be stored in a test plan for use later in the field.

NOTE

If operators use a breaker test plan (See paragraph 9.13) during testing, the test report will also indicate a Pass/Fail condition for each test parameter (i.e contact time, stroke, velocity, etc.).

3.3 Analog Voltage Input Results

The analog voltage, input channel, “V1” measures the breaker's DC control voltage during an operation. Printed voltage readings include nominal voltage, when the supply voltage has no load; and minimum voltage, when the supply voltage is under load or when a coil is energized.

The “V1” connection allows the user to monitor the DC power supply’s voltage fluctuations during a breaker operation. The feature is effective in detecting the breaker’s power supply problem, which normally can not be seen by using a voltmeter.

NOTE

Voltage readings can range from 1 to 255 Vdc.

3.4 Digital Voltage Input Results

The digital voltage, input channel, “V2” monitors the voltage status as “ON” or “OFF” conditions and graphs the result. A voltage level above 30 Vdc is considered as the “ON” state. The input channel is dedicated to monitor the breaker’s auxiliary switch action during a breaker operation.

NOTE

Input voltage ranges from 1 to 300 Vac/dc.

3.5 Initiate Current Results

The CT-7000 not only plots the trip or close current waveforms, but also prints the steady-state current readings of the trip and close coils during an operation. A typical circuit breaker timing report is shown on Figure 10.0.

3.6 Slow-Close Test Results

A Slow-Close test determines the contact touch distance and penetration by using the travel transducer and dry contact channels.

4.0 Test Result Graphics

4.1 Thermal Printer Graphic Printout

A 4.5 inch wide, built-in, thermal printer can output graphic waveforms of the contact channels, travel curves and actuator-coil currents. Using the Zoom Graphics Mode, the user can enlarge the graphical outputs by specifying the timing zone. Typical graphical results are shown in Figures 12.0 and14.0.

4.2 Ink-jet Printer Output

A color graphic report can be printed on the HP Ink-jet printer (supplied with each CT-7000). The CT-7000 will print color graphics of contact channels, travel channels, current wave forms on 8½ by 11-inch paper.

5.0 CT-7000 Controls and Display

Before using the CT-7000, users should become familiar with all of the controls and display indications. The keypad and display are used to operate the CT-7000. Figure 1.0 represents the control panel and the numbered lines pointing to each control and indicator refer to Table 1.0, which describes the function of each control and indicator.

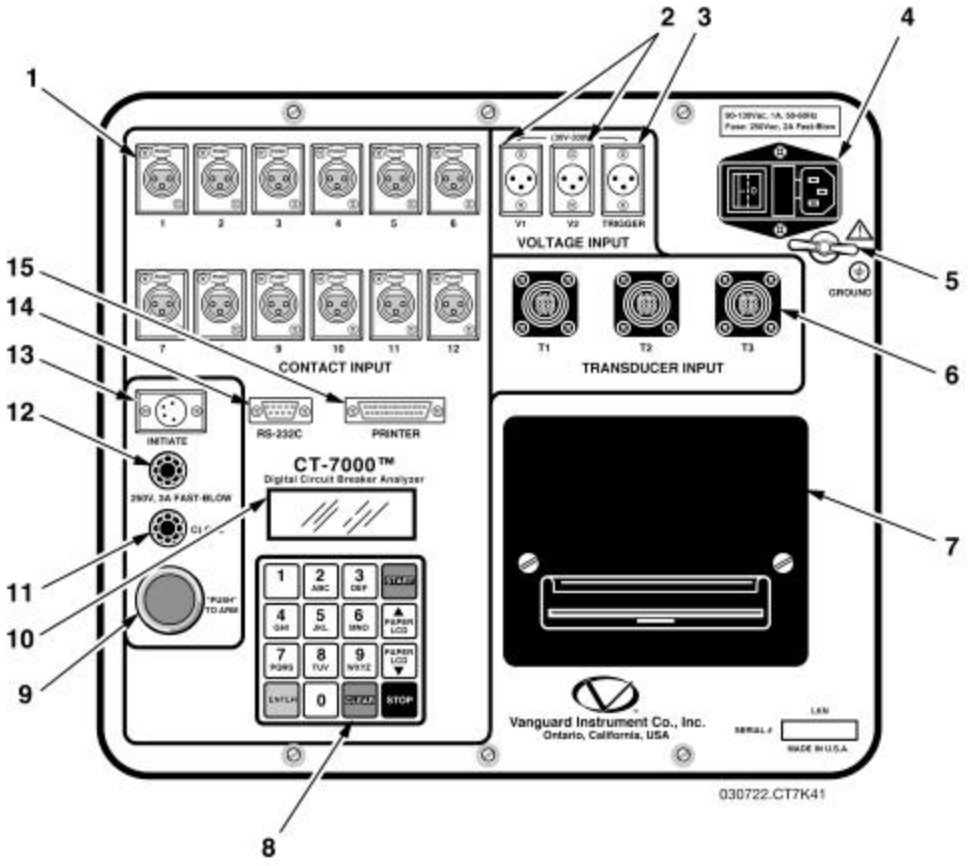


Figure 1.0 CT-7000 Control Panel

Table 1.0 CT-7000 Controls and Displays

Fig. 1.0 Index no.	PANEL MARKING	FUNCTIONAL DESCRIPTION
1	**CONTACT INPUT (1 –12)**	Female connectors for the contact channels.
2	**30-300V V1 & V2 VOLTAGE INPUT**	3-pin connectors. Each input is a voltage detector for the timing voltages of the trip or close coil switching during the active period. Voltage detection level ranges from 30 to 300 Vdc or peak.
3	**30-300V TRIGGER VOLTAGE INPUT**	3-pin connector triggers timing functions. Voltage levels ranging from 30 to 300 Vac, dc or peak.
4	**120/240Vac, 2A, 50-60Hz Fuse: 250Vac, 3A Fast-Blow**	3-wire power plug. 3 Ampere, AC fuses. The ON/OFF switch is a 2-pole rocker.
5	**GROUND**	Safety, ground terminal. 5/16-18 thread stud, with wing nut.
6	**T1, T2, T3 TRANSDUCER INPUT**	16-pin connectors. Each input is a travel encoder input used for contact, motion data.
7	**(Printer; No panel marking)**	Thermal printer. Microprocessor controlled printer that uses specially treated, 4.5 inch wide paper.
8	**1-9, 0, ENTER, START, STOP, CLEAR, - PAPER LCD, ¯ PAPER LCD**	16 button keypad. The keys are momentary-contact, pushbutton switches. Allows users to make menu selections, enter alphanumeric data, adjust the LCD contrast and reposition the printer paper.
9	**“PUSH” TO ARM**	Spring-loaded, pushbutton switch. Press and hold to complete the Trip or Close circuits for breaker tests.
10	**(Display; no panel marking)**	4-line by 20-character, backlit LCD. Displays menus, options, prompts and test result data.
11	**CLOSE 250V, 5A FAST-BLOW**	Close circuit fuse: 5 Ampere, 250V, Fast-Blow.
12	**OPEN 250V, 5A FAST-BLOW**	Open circuit fuse: 5 Ampere, 250V, Fast-Blow.
13	**INITIATE**	4-pin connector used for the switching circuit for operating the circuit breaker under test.
14	**RS-232C**	9-pin connector for serial computer interface.
15	**PRINTER**	Parallel printer port.

6.0 CT-7000 Analyzer Specifications

CONTACT TIMING	Open, Close, Open-Close, Close-Open, and Open-Close-Open.
SIZE & WEIGHT	16d by 14w by 11h (inches), less than 32 pounds.
OPERATING POWER	2 Ampere, 90-120 Vac / 200-240 Vac 50/60 Hz.
TIMING WINDOW	Selectable between: 1, 10, or 20 second.
RESOLUTION	±100 microseconds at 1 second duration. ±1.0 millisecond at 10 second duration. ±2.0 millisecond at 20 second duration.
DRY-CONTACT INPUT	3 or 6 or 12 contact channels. All contact inputs are grounded until testing is started. Each contact detects main and insertion resistor contacts.
CONTACT RESISTANCE	CLOSED: less than 20 Ohms. OPEN: greater than 10,000 Ohms.
INSERTION RESISTANCE	Ranges from 10 to 7,000 Ohms.
TRIGGER INPUT	Open/Close: 30 to 300 Vdc, peak Vac.
VOLTAGE INPUTS	2 voltage inputs, sensitivity ranging from 1.0 to 300 Vdc, peak Vac. Analog voltage recording ranges from 1.0 to 255 Vdc.
CURRENT-SENSOR INPUT	1 non-contact, hall-effect sensor ranging from 0.2 to 20 Amperes, DC to 5 kHz.
BREAKER INITIATE	Initiate Open, Close, Open-Close, Close-Open, Open-Close-Open.
TRAVEL TRANSDUCER INPUT	3 travel-transducer channels. Linear motion from 0.0 to 60.0 inches (±0.01) inch. Rotary ranges from 0 to 360^{o} (± 0.36º).
BREAKER SLOW-CLOSE TEST	Measures the contact point distance.
STORAGE CAPABILITIES	Store 99 Circuit Breaker Test Plans. Store up to 100 timing records.
BREAKER ANALYSIS SOFTWARE (included)	Windows 95, 98, 2000, NT, XP compatible. The analysis software can be installed on a IBM-compatible computer for graphical display, numerical reports and database utility for office use.
COMPUTER INTERFACE	RS-232C Port.
DISPLAY	Backlit LCD screen, 4-lines by 20-characters, sunlight viewable.
HARD-COPY PRINTOUT	Contact travel waveforms and tabulated results printout on 4.5 inch thermal paper.
CARRYING CASE (optional)	Hard shipping case for CT-7000 and cables. Hard shipping case for Travel Transducers.
WARRANTY	One year warranty on parts and labor. Post-warranty service contracts available.

7.0 CT-7000 Special Features

7.1 CT-7000 Supplied Cables

Table 2.0 CT-7000 Cable set

ITEM	DESCRIPTION	QTY
1	GND Cable	1
2	Power Cord	1
3	Contact Cable	3 or 6 or 12
4	Contact Extension Cable	3 or 6 or 12
5	Transducer cable	1
6	Voltage & Trigger Leads	3
7	Voltage & Trigger Extension cables	3
8	Initiate Lead	1
9	Initiate Extension Cable	1
10	RS-232C Cable	1

7.2 CT-7000 Operating Voltages

The CT-7000 operating voltage is selectable between 110/120 Vac, 50/60 Hz or 220/240 Vac, 50/60 Hz. Voltage selection is set by the JP1 connector on the Power Supply board and the JP3 connector on the Initiate board of the CT-7000. The jumper settings for the connectors are shown in Table 3.0.

Table 3.0 Voltage Selection Jumper Setting

VOLTAGE SELECTION	CONNECTOR PIN
110-120 Vac	Pin 1& 2, 3 & 4
220-240 Vac	Pin 2 & 3

An initiate circuit relay with the corresponding operating voltage must also be installed in the CT-7000 Initiate board.

NOTE

The factory sets the operating voltage.

7.3 CT-7000 Main Power Fuse

The CT-7000 uses an AC input module that contains the AC receptacle, power switch and protective fuses. The 3 Ampere replacement fuses should be 20mm, 250Vac, fast-blow types.

NOTE

The OPEN and CLOSE initiate are 5 Ampere fuses that should be 3AG, 250Vac, fast-blow types.

7.4 CT-7000 Printer and Printer Paper

The built-in, thermal printer uses 4.5 inch wide, thermal paper for printing test results. To maintain the highest, quality printing and to avoid paper jamming, it is highly recommended that the thermal paper be supplied by the factory. Additional paper can be ordered from either of the two sources listed below:

Vanguard Instruments Co, Inc.
1710 Grevillea Court
Ontario, CA 91761
Tel: 909-923-9390
Fax: 909-923-9391
Part Number: TP-4 Paper

BG Instrument Co.
13607 E. Trent Avenue
Spokane, WA 99216
Tel: 509-893-9881
Fax: 509-893-9803
Part Number: TP-4 paper

7.5 CT-7000 Printer Paper Control

To advance the paper from the printer, press and release the "↑ PAPER LCD" button. To retract the thermal paper from the printer, press and release the "↓ PAPER LCD" button.

7.6 Replacing CT-7000 Thermal Paper

The roll of thermal paper resides inside a pocket underneath the printer cover. To replace the paper, follow the steps below:

- Remove the printer cover.
- Remove the leftover thermal paper roll from the paper holder.
- Unroll the new thermal paper.
- Feed the thermal paper into the slot between the paper pocket and the rubber roller. The printer will automatically pull the paper under the thermal head.
- Place the paper roll into the paper holder.
- Lift the thermal head and align the thermal paper if necessary.
- Replace the printer cover back.

NOTE

The thermal paper will show a red stripe in the margin to indicate that the roll is about to run out of paper.

7.7 CT-7000 LCD Contrast Control

To darken the LCD screen, press and hold the "↑ PAPER LCD" button, while to decrease the contrast of the LCD screen, press and hold the "↓ PAPER LCD" until the desired contrast is reached.

8.0 Test Hook-up Connections

8.1 Contact Cable Hookup

A typical, contact cable connection to a circuit breaker is shown in Figure 2.0. Red clips are connected to phase A, B and C of the breaker's bushings. The black clips are connected on the grounded or common, side of the bushings. For circuit breakers with series contacts, connect the contact cables as shown in Figure 3.0.

NOTE

It is advisable to ground one side of the contacts for most testing purposes. If a breaker is floating or ungrounded, ensure that the contact channel inputs are protected against static discharge.

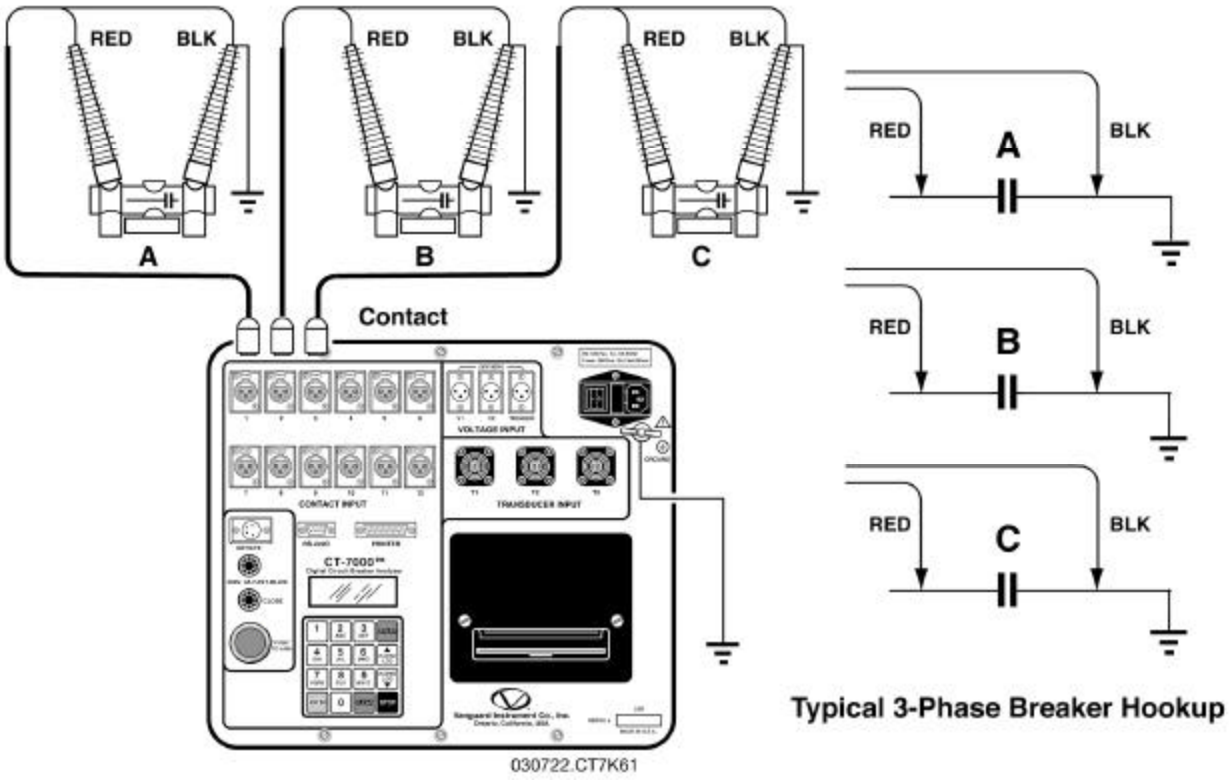


Figure 2.0 Contact Cable Connection

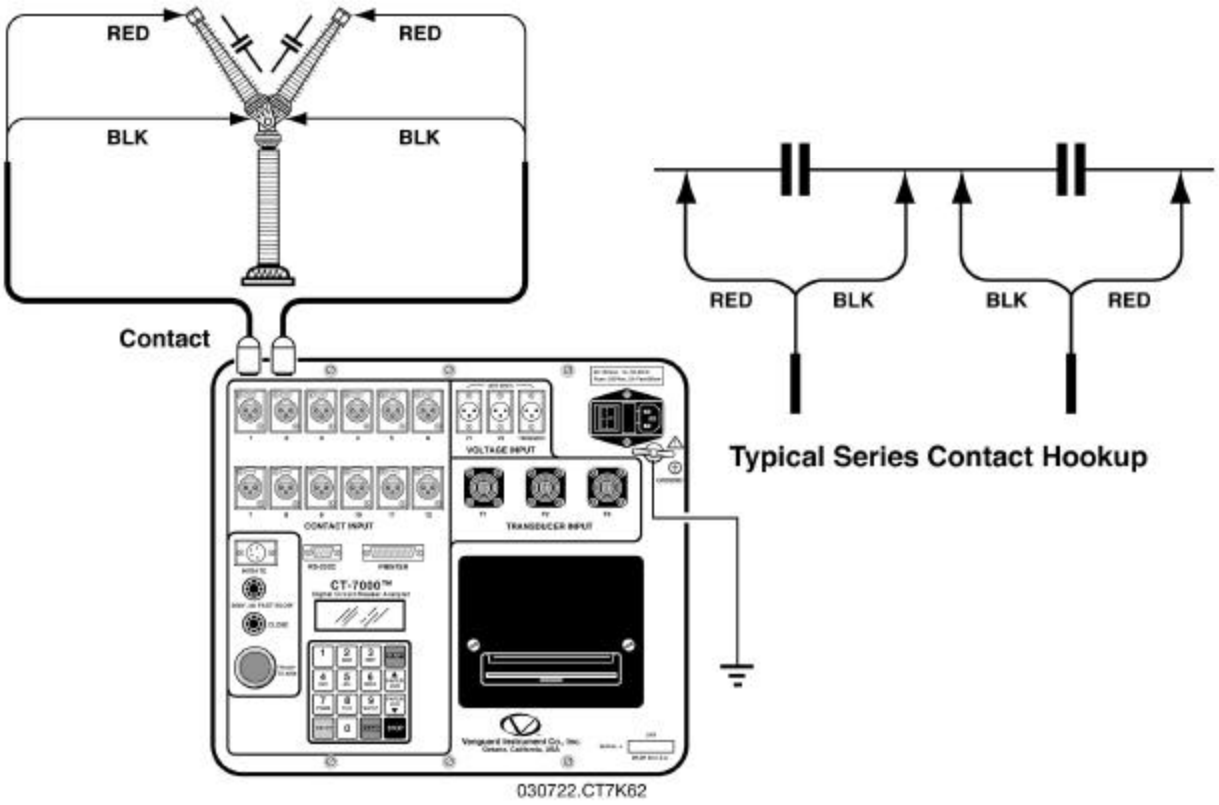


Figure 3.0 Series Contact Cable Connection

8.2 Initiate Cable Hookup

The CT-7000 will trip or close breakers through a solid-state device, which will operate on any AC or DC control voltage ranging from 10 to 300 Volts. Both the trip and close circuits are protected by 5 Ampere fuses.

A typical DC trip and DC close, control circuit test hookup is shown in Figure 4.0.

A typical DC trip and AC close, control circuit test hookup is shown in Figure 5.0.

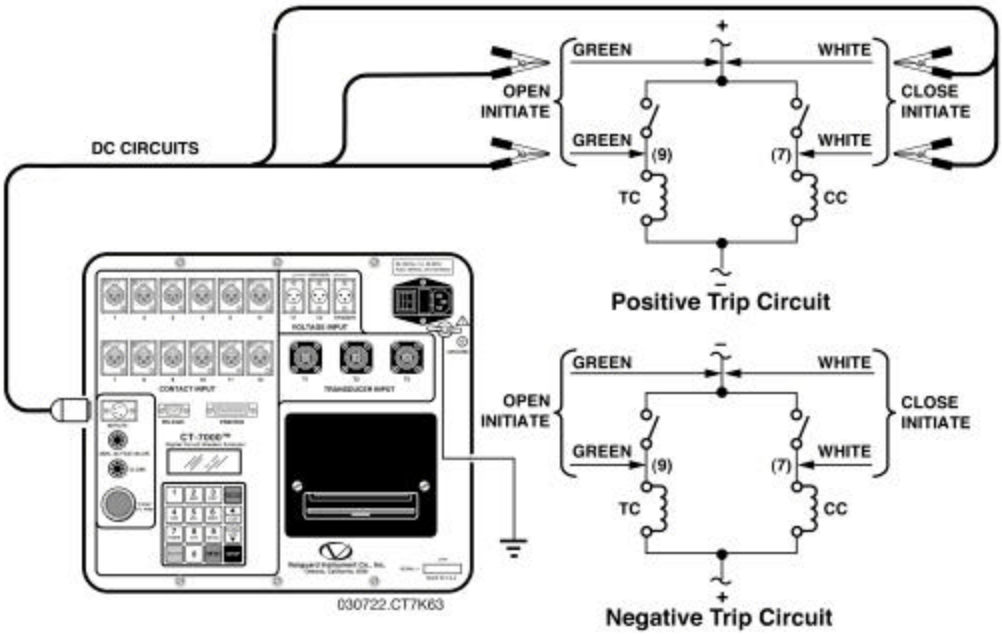


Figure 4.0 DC Trip and DC Close, Initiate Circuit Cable Hook-Up

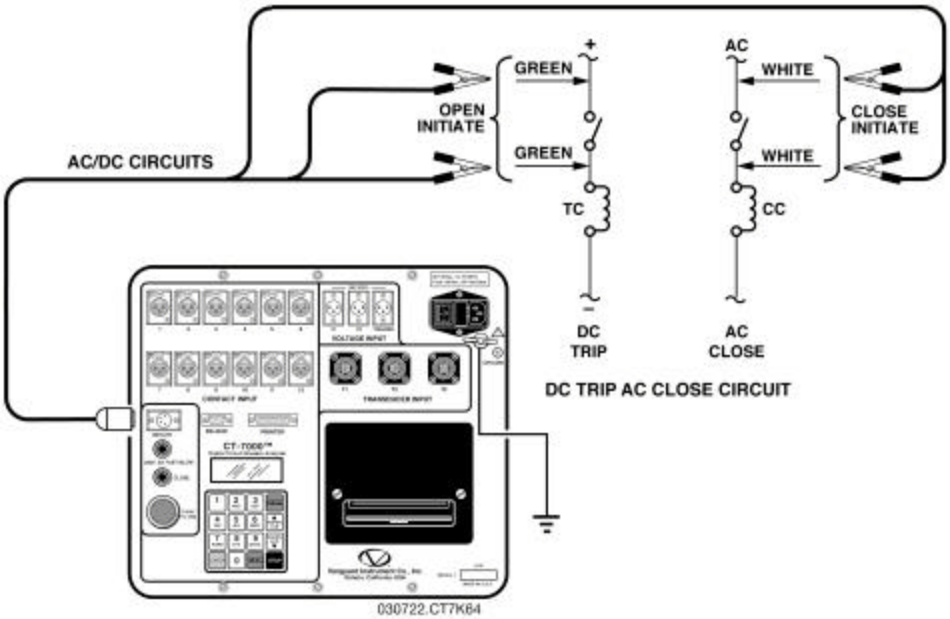


Figure 5.0 DC Trip and AC Close, Initiate Circuit Cable Hook-Up

8.3 Analog Voltage Monitor Hookup

The analog, voltage input, “V1” permits the user to monitor a breaker's DC control voltage during an operation. The analog, voltage input will record the nominal DC voltage at no load and the minimum DC voltage while the Trip or Close coil is energized.

The nominal and minimal voltage readings will be printed on a tabulated report. Analog waveforms will also be plotted in a graphical format. Thus, the user is able to see the breaker's DC control voltage "dip" under load conditions. Problems, such as a poor connection or an excessive voltage drop, during operation can be easily detected.

A typical voltage monitoring hook up scheme is shown on Figure 6.0.

NOTE

The maximum voltage that can be recorded is set at 255 Vdc.

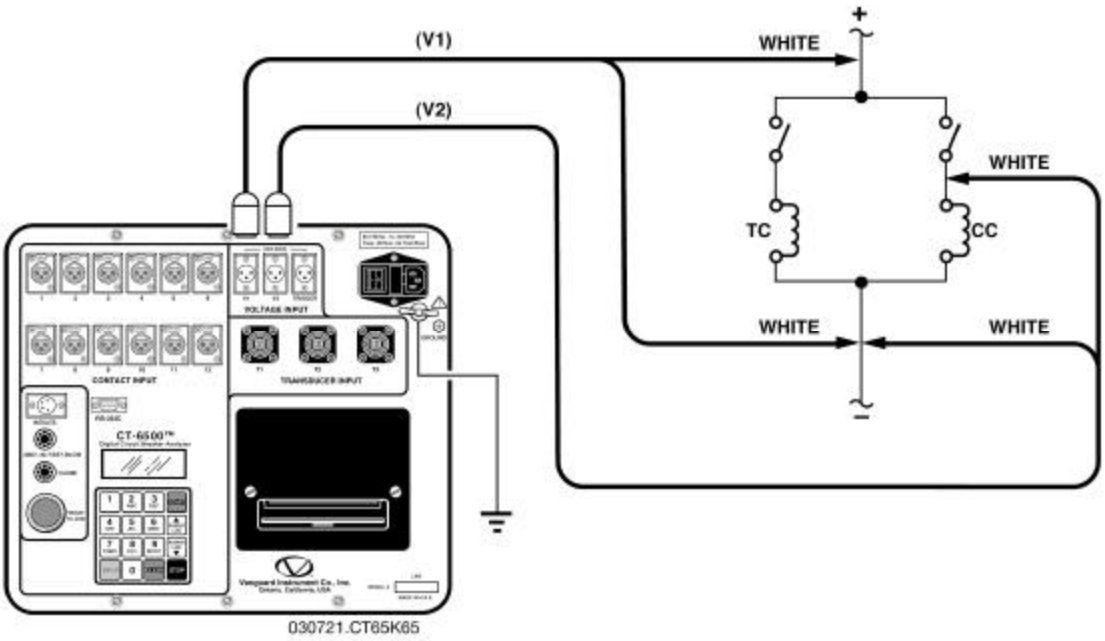


Figure 6.0 Voltage Monitoring Cable Hook-Up

8.4 Digital Voltage Monitor Hookup

The digital, voltage input channel, “V2” permits the user to monitor the voltage status as “ON” or “OFF” states. The voltage “ON” or “OFF” states will be plotted on the graphical report. A typical hook up is shown in Figure 6.0.

8.5 External Trigger Input

The External Trigger Mode enables the user to start recording data when the CT-7000 senses a voltage. A typical application for the External Trigger Mode is to time a circuit breaker in a close operation and to start timing only when the close coil is energized, thus bypassing the 52X relay delay time.

Since the 52X relay carries the close coil current, the user will need to connect the CT-7000's initiate cable to the close terminal shown in Figure 4.0. The CT-7000 will energize the 52X relay to start the close operation, which will then start the timing when the CT-7000 senses the voltage across the closing coil. See Figure 7.0 for a typical test hookup. Another application for external trigger is to start timing the breaker when the user trips or closes the breaker remotely.

NOTE

Minimum trigger voltage is set for 30 Vac/dc. Maximum, continuous voltage is limited at 300 Vac/dc. Different trigger voltages can be set at the factory, based upon specific requests.

The CT-7000 will start looking for the external trigger voltage when the message, "AWAITING TRIGGER…" is shown on the LCD screen. The external trigger voltage needs to be sensed by the CT-7000 within 30 seconds after the initiate sequence has begun. The CT-7000 will return to the main menu if no voltage is sensed.

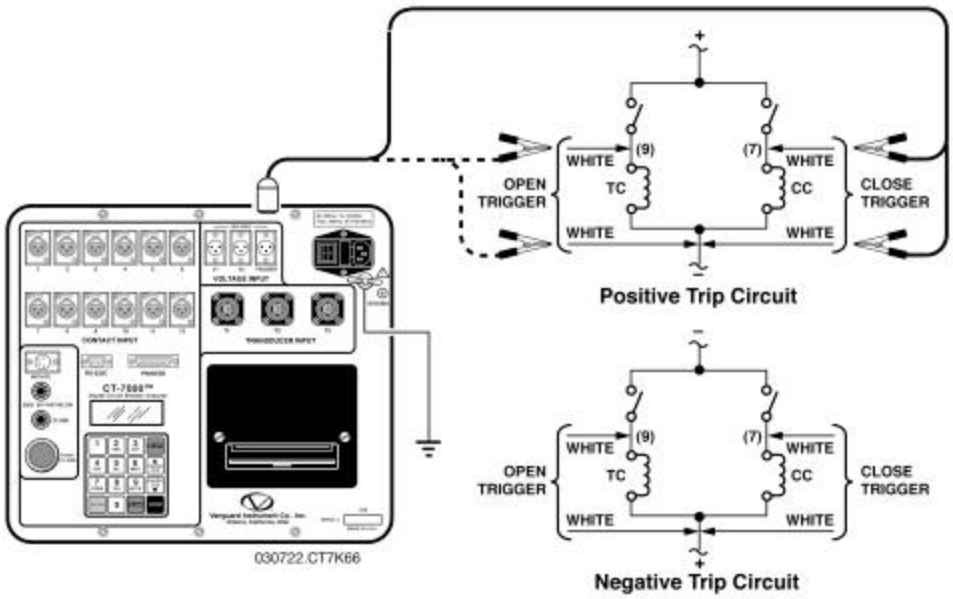


Figure 7.0 External Trigger Cable Hook-Up

8.6 Transducer Connection

A typical transducer connection is shown on Figure 8.0. See Appendix I for more transducer connections.

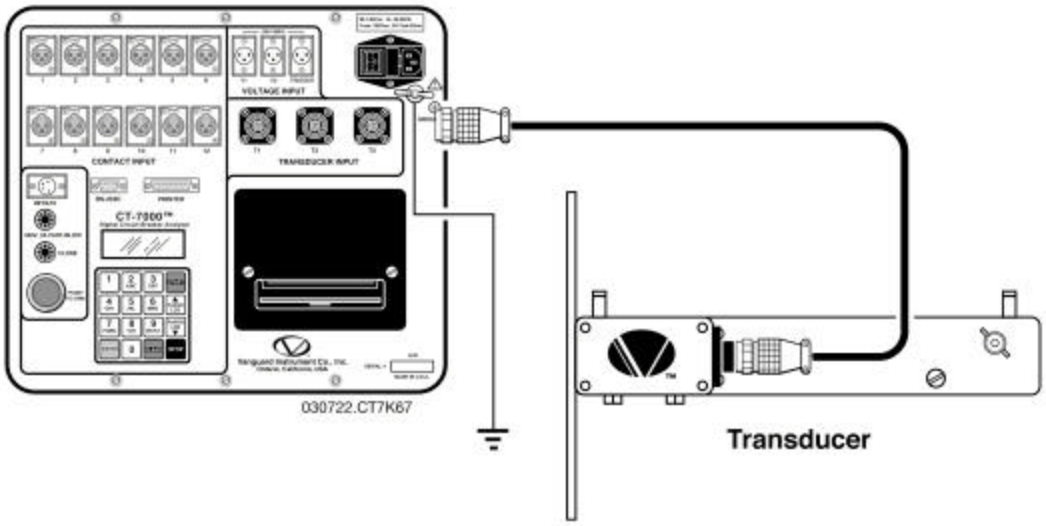


Figure 8.0 Transducer Connection

9.0 Operating Procedures

The main steps to time a circuit breaker are listed in Figure 9.0.

.

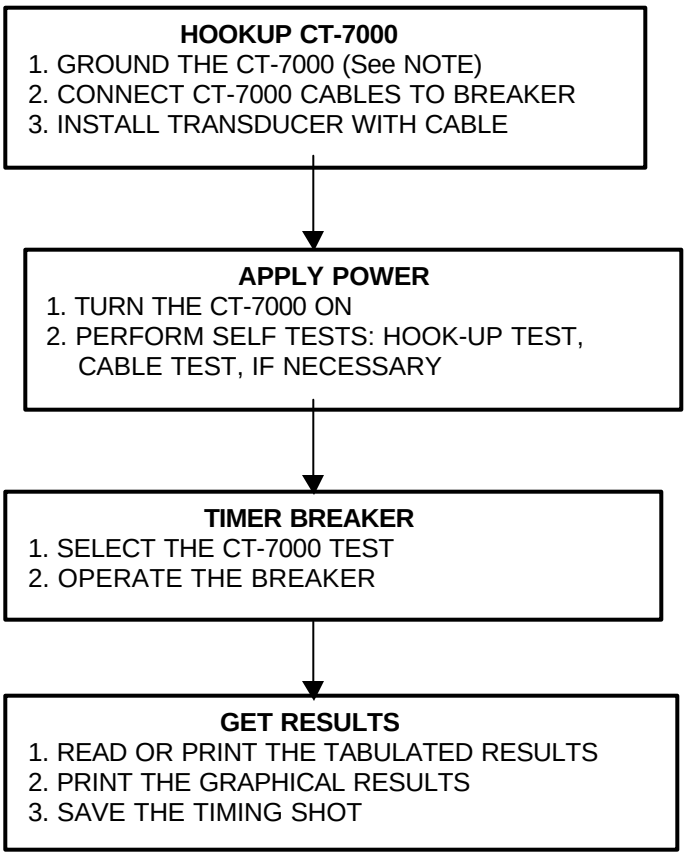


Figure 9.0 CT-7000 Operating Steps

NOTE

To reduce the possibility of damaging the CT-7000 contact channels due to static discharge in the high voltage substations, it is recommend to ground one side of the breaker's bushings.

9.1 Timing a Circuit Breaker

The CT-7000 will initiate the breaker operation and do a timing test on the following operations:

- OPEN
- CLOSE
- OPEN-CLOSE
- CLOSE-OPEN
- OPEN-CLOSE-OPEN

NOTE

1. The CT-7000 can start the OPEN-CLOSE operations without a delay or by using a programmable delay between the OPEN and CLOSE commands.

2. The CLOSE-OPEN can be started by the CT-7000, using several options.

- Contact #1 Close

  The CT-7000 can initiate a CLOSE command and then an OPEN command after detecting the breaker's contact was closed. The CT-7000 detects that the breaker's contact was closed through contact channel #1. The selection is recommended for the CLOSE-OPEN operation since it truly represents when the circuit breaker closed and then opened.

- Set DELAY

  The CT-7000 can initiate a CLOSE command and then an OPEN command after a programmable delay that can be set in milliseconds.

- No DELAY

  The CT-7000 can initiate a CLOSE command and then an OPEN command without any delay. Since the circuit breaker is in the open state, the circuit breaker's 52B contact allows the close coil to be energized, which can start the close command. When the circuit breaker is making the transition from an open state to a close state, the 52A contact will close allowing the breaker to initiate the open command.

3. The OPEN-CLOSE-OPEN operations can be initiated by the CT-7000, by using a programmable delay between each of the operations, where the delays can be set between the OPEN to CLOSE and between the CLOSE to OPEN commands.

9.1.1 Timing an OPEN Operation With No Insertion Resistors

Table 4.0 Open Operation With No Insertion Resistors

STEP	OPERATION	ACTION	DISPLAY
1	READY TIMER FOR BREAKER OPERATION.	PRESS #1 KEY.	INSERTION RESISTOR? 1.NO 2.YES
2	SELECT NO INSERTION RESISTOR.	PRESS #1 KEY.	TIMING WINDOWS: 1.WINDOW = 1 SEC 2.WINDOW = 10 SEC 3. WINDOW = 20 SEC
3	SELECT 1-SECOND TIMING WINDOW.	PRESS #1 KEY.	TRIGGER MODE: 1. Internal Trigger 2. External Trigger
4	SELECT INTERNAL TRIGGER.	PRESS #1 KEY.	TIMING MODE: 1. OPEN 2. CLOSE 3. O-C 4. C-O 5. O-C-O
5	SELECT OPEN OPERATION.	PRESS #1 KEY.	OPEN TIMING Hold "ARM" Switch, Then "START". "STOP" to ABORT
6	INITIATE OPEN COMMAND.	HOLD THE "ARM" SWITCH AND PRESS THE "START" KEY.	TEST IN PROGRESS Hold "ARM" Until Test complete. (Up to 15 seconds)
7	OBSERVE BREAKER OPERATED. ANALYZER IS READY TO OUTPUT RESULTS.	NONE.	1.TIME BREAKER 2.GET RESULT 3.SET-UP 4.DIAGNOSTIC

NOTE

One-second timing windows are used for breaker timing. The 10 and 20 second timing windows are used for circuit-switcher timing.

9.1.2 Timing an OPEN Operation With Insertion Resistors

The CT-7000 can time breakers with insertion resistors. The insertion resistor can range from 10 to 7,000 Ohms. Any insertion resistor more than 7,000 Ohms is detected as an open circuit. The timing window results will show the main contact time and the insertion resistor contact time. Graphic reports will show the main contact and the resistor contact activities on each of the channels.

Table 5.0 Open Operation With Insertion Resistor

STEP	OPERATION	ACTION	DISPLAY
1	READY TIMER FOR BREAKER OPERATION.	PRESS #1 KEY.	INSERTION RESISTOR? 1.NO 2.YES
2	SELECT INSERTION RESISTOR.	PRESS #2 KEY.	RESISTOR VALUE: 1.LESS THAN 1000 OHM 2.1000 to 2000 OHM 3.MORE THAN 2000 OHM
3	SELECT LESS THAN 1000 OHM RESISTOR RANGE.	PRESS #1 KEY.	TIMING WINDOWS: 1.WINDOW = 1 SEC 2.WINDOW = 10 SEC 3.WINDOW = 20 SEC
4	SELECT 1-SECOND WINDOW.	PRESS #1 KEY.	TRIGGER MODE: 1. Internal Trigger 2. External Trigger
5	SELECT INTERNAL TRIGGER.	PRESS #1 KEY.	TIMING MODE: 1. OPEN 2. CLOSE 3. O-C 4. C-O 5. O-C-O
6	SELECT OPEN OPERATION.	PRESS #1 KEY.	OPEN TIMING Hold "ARM" Switch, Then "START". "STOP" to ABORT
7	INITIATE OPEN COMMAND.	HOLD THE "ARM" SWITCH AND PRESS THE "START" KEY.	TEST IN PROGRESS Hold "ARM" Until Test complete. (Up to 15 seconds)
8	ANALYZER IS READY TO OUTPUT RESULTS.	NONE.	1.TIME BREAKER 2.GET RESULT 3.SET-UP 4.DIAGNOSTIC

NOTE

The user can set the CT-7000 to print tabulated and graphical reports automatically after it completes a test. See Paragraph 9.21 for the automatic print setting.

9.1.3 Timing CLOSE-OPEN Operation Using Contact Channel #1

The CLOSE-OPEN operation of the breaker simulates a condition where a breaker is closed on a fault. There are 3 choices for the user to setup the CLOSE-OPEN operation:

1. Contact #1 CLOSE
   Open operation is initiated after contact channel # 1 is closed. Refer to Table 6.0 on the next page.
2. Set DELAY
   The user can set a delay from 10 to 500 ms between a CLOSE command to the OPEN command.
3. No DELAY
   Both the CLOSE and OPEN commands are initiated by the CT-7000 simultaneously. The OPEN coil is energized when the Open auxiliary switch makes.

NOTE

If the Contact #1 CLOSE choice is used, the CT-7000 will first initiate a CLOSE command and then send an OPEN command only when it detects that the main contact #1 is closed. The mode truly simulates when the breaker is closing on a fault condition in the field.

Table 6.0 Close-Open Operation Using Contact Channel #1

STEP	OPERATION	ACTION	DISPLAY
1	READY TIMER FOR BREAKER OPERATION.	PRESS #1 KEY.	INSERTION RESISTOR? 1.NO 2.YES
2	SELECT NO INSERTION RESISTOR.	PRESS #1 KEY.	TIMING WINDOWS: 1.WINDOW = 1 SEC 2.WINDOW = 10 SEC 3.WINDOW = 20 SEC
3	SELECT 1-SECOND WINDOW.	PRESS #1 KEY.	TRIGGER MODE: 1.Internal Trigger 2.External Trigger
4	SELECT INTERNAL TRIGGER.	PRESS #1 KEY.	TIMING MODE: 1. OPEN 2. CLOSE 3. O-C 4. C-O 5. O-C-O
5	SELECT CLOSE-OPEN OPERATION.	PRESS #4 KEY.	C-O Second Trigger: 1. Contact #1 CLOSE 2. Set DELAY 3. No DELAY
6	SELECT CONTACT #1 CLOSE.	PRESS #1 KEY.	CLOSE-OPEN TIMING Hold "ARM" Switch, Then "START". "STOP" to ABORT
7	INITIATE OPEN COMMAND.	HOLD THE "ARM" SWITCH AND PRESS THE "START" KEY.	TEST IN PROGRESS Hold "ARM" Until Test complete. (Up to 15 seconds)
8	ANALYZER IS READY TO OUTPUT RESULTS.	NONE.	1.TIME BREAKER 2.GET RESULT 3.SET-UP 4.DIAGNOSTIC

NOTE

1. Users can program a delay from 10 to 500 ms between the CLOSE and OPEN commands. When a delay is used in the operation, it may not represent a true breaker operating condition.

2. Users can also program in no delay for the operation in which case, the CLOSE and OPEN commands are initiated at the same time by the CT-7000.

9.1.4 Timing OPEN-CLOSE-OPEN Operation

The OPEN-CLOSE-OPEN operation requires the user to enter two time-delays between the circuit breaker operations. The time delays are in millisecond intervals. The first delay is from the first OPEN command to the CLOSE command. The second delay is from the CLOSE command to the second OPEN command. Refer to Table 7.0 for setting up the OPEN-CLOSE-OPEN operation.

Table 7.0 Open-Close-Open Operation Using Delay

STEP	OPERATION	ACTION	DISPLAY
1	READY TIMER FOR BREAKER OPERATION.	PRESS #1 KEY.	INSERTION RESISTOR? 1.NO 2.YES
2	SELECT NO INSERTION RESISTOR.	PRESS #1 KEY.	TIMING WINDOWS: 1.WINDOW = 1 SEC 2.WINDOW = 10 SEC 3.WINDOW = 20 SEC
3	SELECT 1-SECOND WINDOW.	PRESS #1 KEY.	TRIGGER MODE: 1.Internal Trigger 2.External Trigger
4	SELECT INTERNAL TRIGGER.	PRESS #1 KEY.	TIMING MODE: 1. OPEN 2. CLOSE 3. O-C 4. C-O 5. O-C-O
5	SELECT OPEN-CLOSE-OPEN OPERATION.	PRESS #5 KEY.	O-C Delay in mS: (10 – 350) mSec ENTER when done
6	SELECT DELAY BETWEEN OPEN-CLOSE OPERATION.	ENTER DELAY USING 0-9 KEYS, PRESS THE “ENTER” KEY TO CONFIRM.	C-O Delay in mS: (10 – 350) mSec ENTER when done
7	SELECT DELAY BETWEEN CLOSE-OPEN OPERATION.	ENTER DELAY USING 0-9 KEYS, PRESS THE “ENTER” KEY TO CONFIRM.	OPEN-CLOSE-OPEN TIMING Hold "ARM" Switch, Then "START". "STOP" to ABORT
8	INITIATE O-C-O COMMAND.	HOLD THE "ARM" SWITCH AND PRESS THE "START" KEY.	TEST IN PROGRESS Hold "ARM" Until Test complete. (Up to 15 seconds)
9	ANALYZER IS READY TO OUTPUT RESULTS.	NONE.	1.TIME BREAKER 2.GET RESULT 3.SET-UP 4.DIAGNOSTIC

9.2 Get Tabulated Timing Results Using the Thermal Printer

The circuit breaker timing results can be printed on the thermal printer by using the steps listed in Table 8.0.
A typical circuit breaker timing result printed on thermal printer is shown in Figure 10.0.
A typical circuit breaker timing result printed on ink-jet printer is shown in Figure 11.0.

Table 8.0 Get Tabulated Results

STEP	OPERATION	ACTION	DISPLAY
1	GET TIMING RESULTS.	PRESS #2 KEY.	1.PRINT TEST RESULTS 2.PLOT FULL CHART 3.PLOT EXPANSION 4.PLOT 0-200 MS
2	PRINT TABULATED RESULTS.	PRESS #1 KEY.	SELECT PRINTER 1. INTERNAL THERMAL 2. EXTERNAL INK JET 3. DISPLAY RESULTS
3	OUTPUT TABULATED RESULTS ON THERMAL PRINTER.	PRESS #1 KEY.	BUSY PRINTING

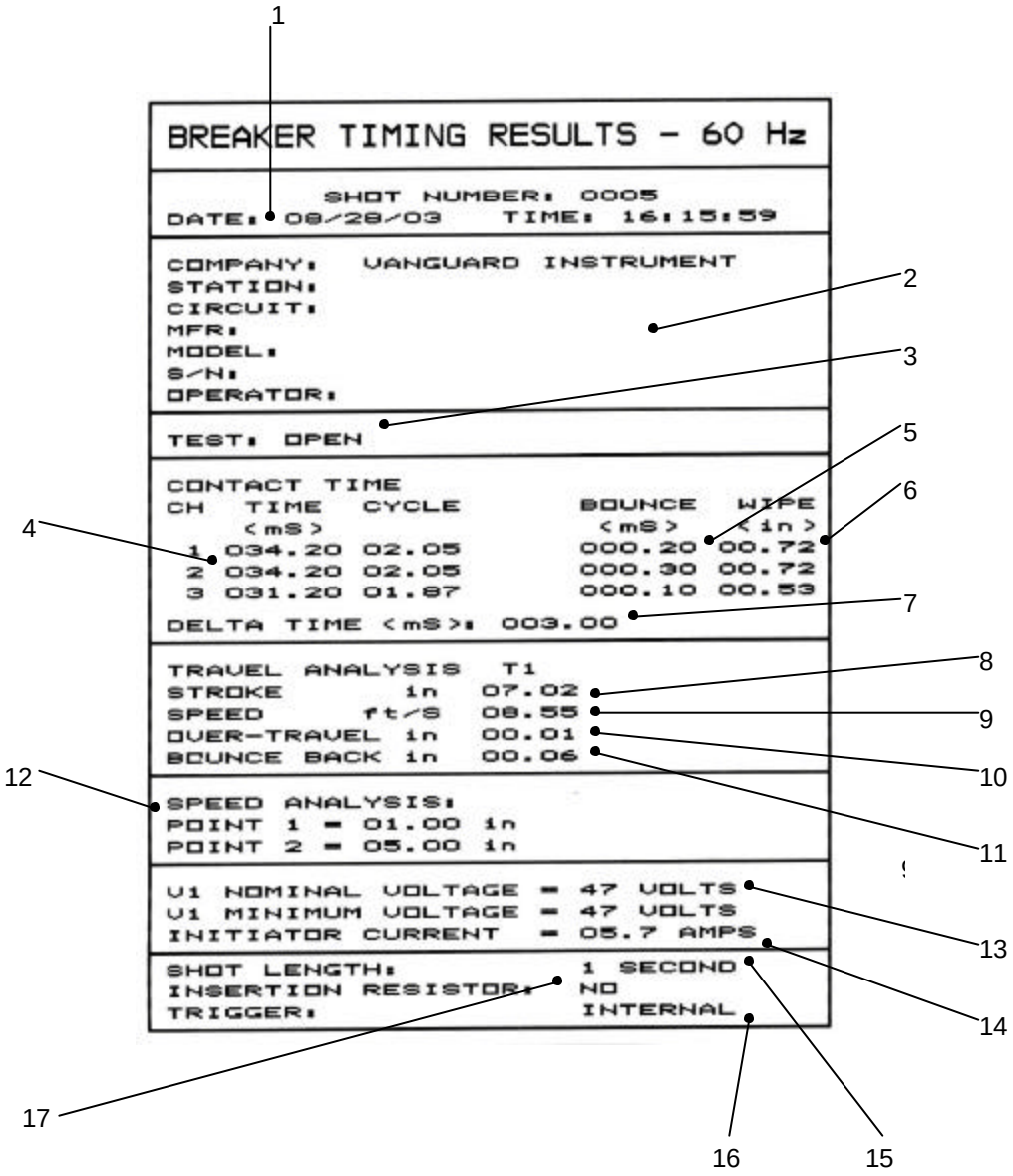


Figure 10.0 Typical Tabulated Printout of an Open Operation From the Thermal Printer

9.2.1 Tabulated Results Interpretation

1. Timing Record is time and date stamped by the CT-7000.

2. Timing record header information (Company, Substation name, Circuit, etc) is also saved with test record.

3. Timing test type (OPEN, CLOSE, O-C, C-O, O-C-O) is identified. An OPEN timing shot is shown in figure 10.0.

4. Contact channel #1 time is shown in both milliseconds and cycles. From Figure 10.0, contact channel #1 time was 34.20 ms or 2.05 cycles.

5. Contact channel #1 bounce duration was 0.20 ms.

6. Contact channel #1 wipe was measured as 0.72 inches.

7. The slowest contact and fastest contact differential time is shown as contact delta, 3.00 ms.

8. Breaker contact stroke was measured as 7.02 inches.

9. Contact velocity calculation was 8.55 feet per second.

10. Contact over-travel distance was measured as 0.01 inches.

11. Contact bounce-back distance was measured 0.06 inches.

12. Contact velocity calculation was from the two analysis points:
    Analysis point # 1 was 1.00 inch from the fully closed position.
    Analysis point # 2 was 5.00 inches from the fully closed position.

13. The DC power supply was monitored during the test. The nominal voltage was 47 Volts and the minimum voltage was 47 Volts.

14. Initiate current was 5.7 Amperes.

15. Timing shot duration was one second.

16. Trigger mode was internal therefore the timing window starts at the same time when the CT-7000 energized the circuit breaker.

17. There was no insertion resistor in the test, thus no insertion resistor time was measured.

BREAKER TIMING RESULTS - 60 Hz

SHOT NUMBER: 0002
DATE: 09/25/03 TIME: 14:42:55

COMPANY:
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
OPERATOR:

TEST: OPEN

CONTACT TIME

CH	TIME (mS)	CYCLE	BOUNCE (mS)	WIPE (in)
1	034.20	02.05	001.20	00.71
2	034.30	02.06	000.20	00.72
3	031.20	01.87	000.10	00.53

Contact Delta Time (mS) = 003.10

CT CHANNEL ANALYSIS

TIME (mS)	CYCLE
000.00	00.00

TRAVEL ANALYSIS T1

STROKE	in	06.99
SPEED	ft/S	08.53
OVER-TRAVEL	in	00.04
BOUNCE BACK	in	00.03

SPEED ANALYSIS:
POINT 1 = 01.00 in
POINT 2 = 05.00 in

V1 NOMINAL VOLTAGE = 49 VOLTS V1 MINIMUM VOLTAGE = 47 VOLTS
INITIATOR CURRENT = 05.1 AMPS

SHOT LENGTH: 1 SECOND
INSERTION RESISTOR: NO
TRIGGER: INTERNAL

Figure 11.0 Typical Tabulated Printout of an Open Operation From Ink Jet Printer

9.3 Get Graphic Timing Results Using the Thermal Printer

Selecting the "PLOT FULL CHART" command will plot the timing chart as follows:

- Timing chart from 0 to 1000 ms with one second window and 50 ms time markers.
- Timing chart from 0 to 10 seconds with 10 second window and 500 ms time markers.
- Timing chart from 0 to 20 seconds with 20 second window and one second time markers.

Table 9.0 Plot Chart and Tabulated Report

STEP	OPERATION	ACTION	DISPLAY
1	GET TIMING RESULTS.	PRESS #2 KEY.	1. PRINT TEST RESULTS 2. PLOT FULL CHART 3. PLOT EXPANSION 4. PLOT 0-200 MS
2	PLOT FULL CHART.	PRESS #2 KEY.	SELECT PRINTER 1. INTERNAL THERMAL 2. EXTERNAL INK JET
3	SELECT THERMAL PRINTER.	PRESS #1 KEY.	PLEASE WAIT PLOTTING GRAPH
4	RETURN TO MAIN MENU AFTER PRINT CHART.	NO ACTION.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

NOTE

1. Plot Expansion, which is Selection #3, in Step 1, allows the user to expand the graphic results in 100 ms increments.

2. Selecting "PLOT 0-200 MS" will automatically plot the timing chart from 0 to 200 milliseconds in the expansion mode with 10 ms timing markers, which can be seen in Figure 14.0.

3. Graphical result interpretations are shown in Figures 16.0, 17.0 and 18.0.

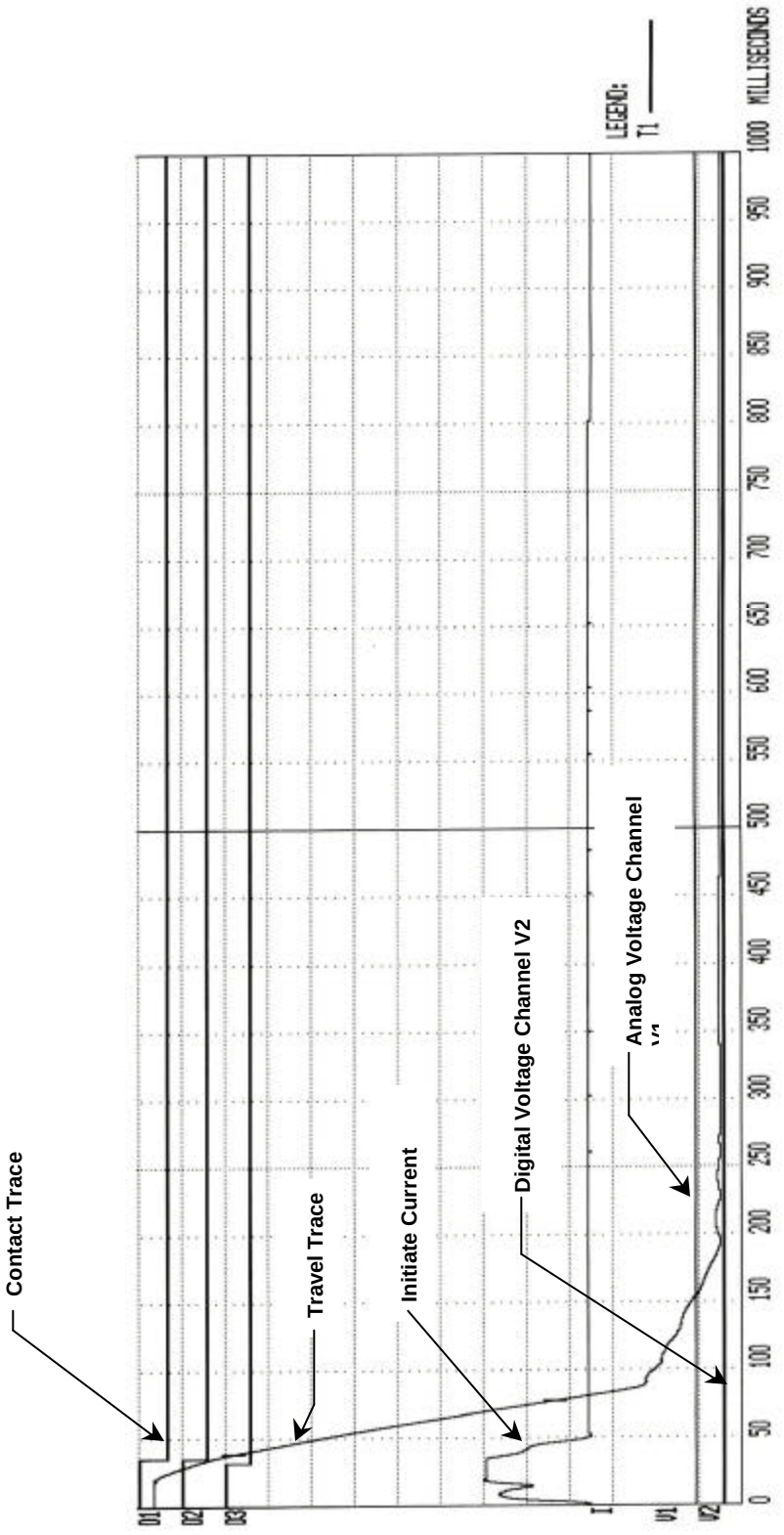


Figure 12.0 Typical Graphic Result From the Thermal Printer

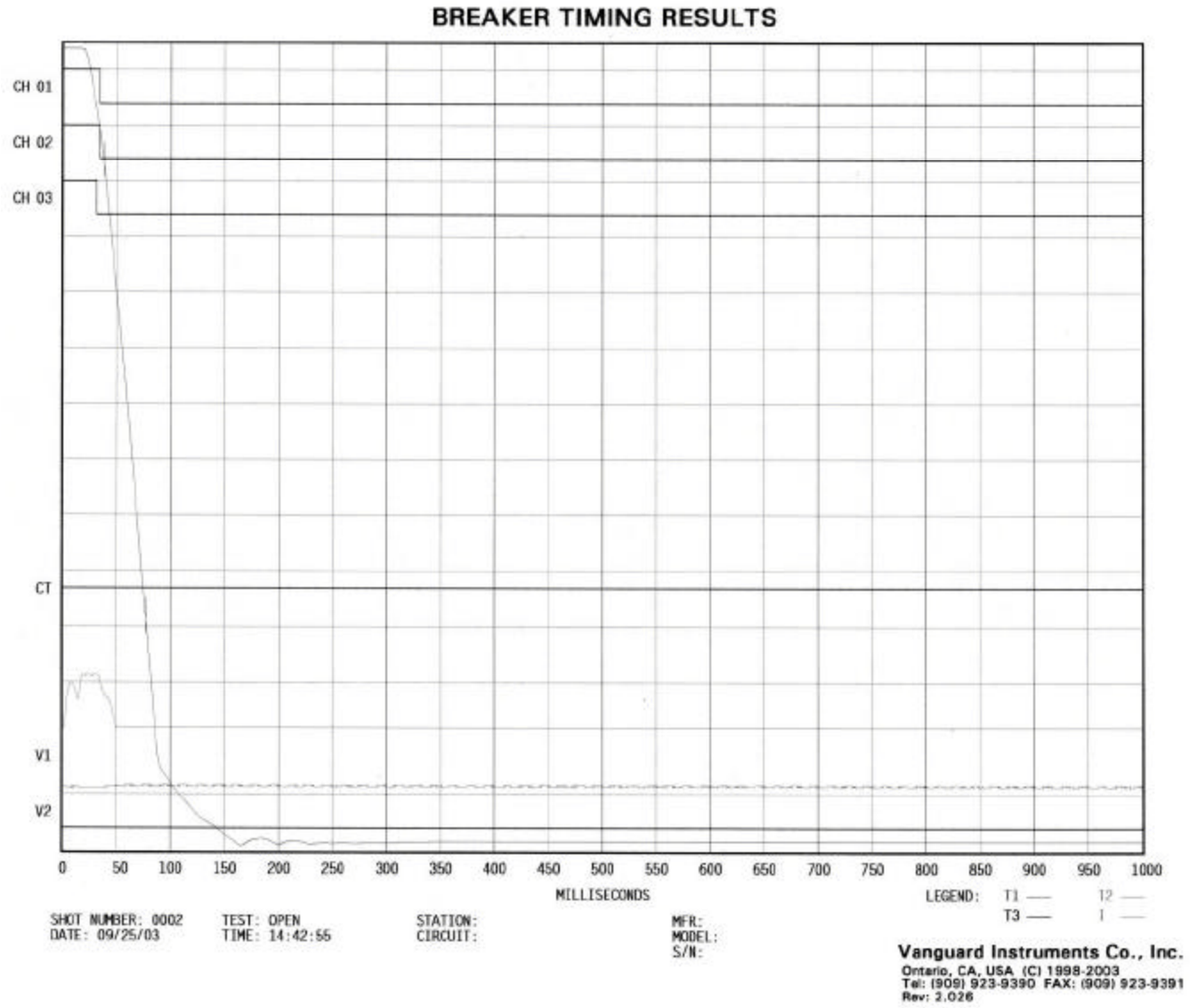


Figure 13.0 Typical Graphic Printout From the Ink Jet Printer

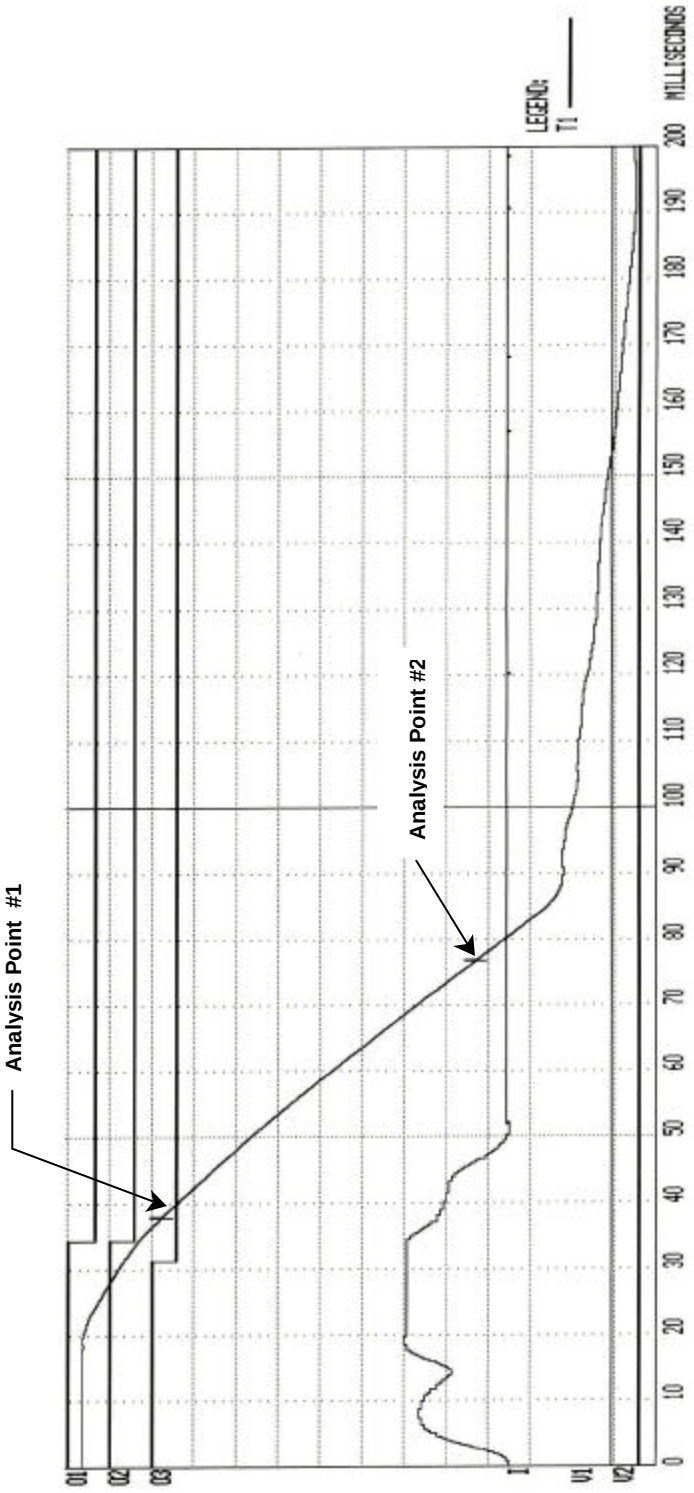


Figure 14.0 Expansion Graph From 0 to 200ms From the Thermal Printer

NOTE

Analysis point # 1 and point #2 are shown on chart.

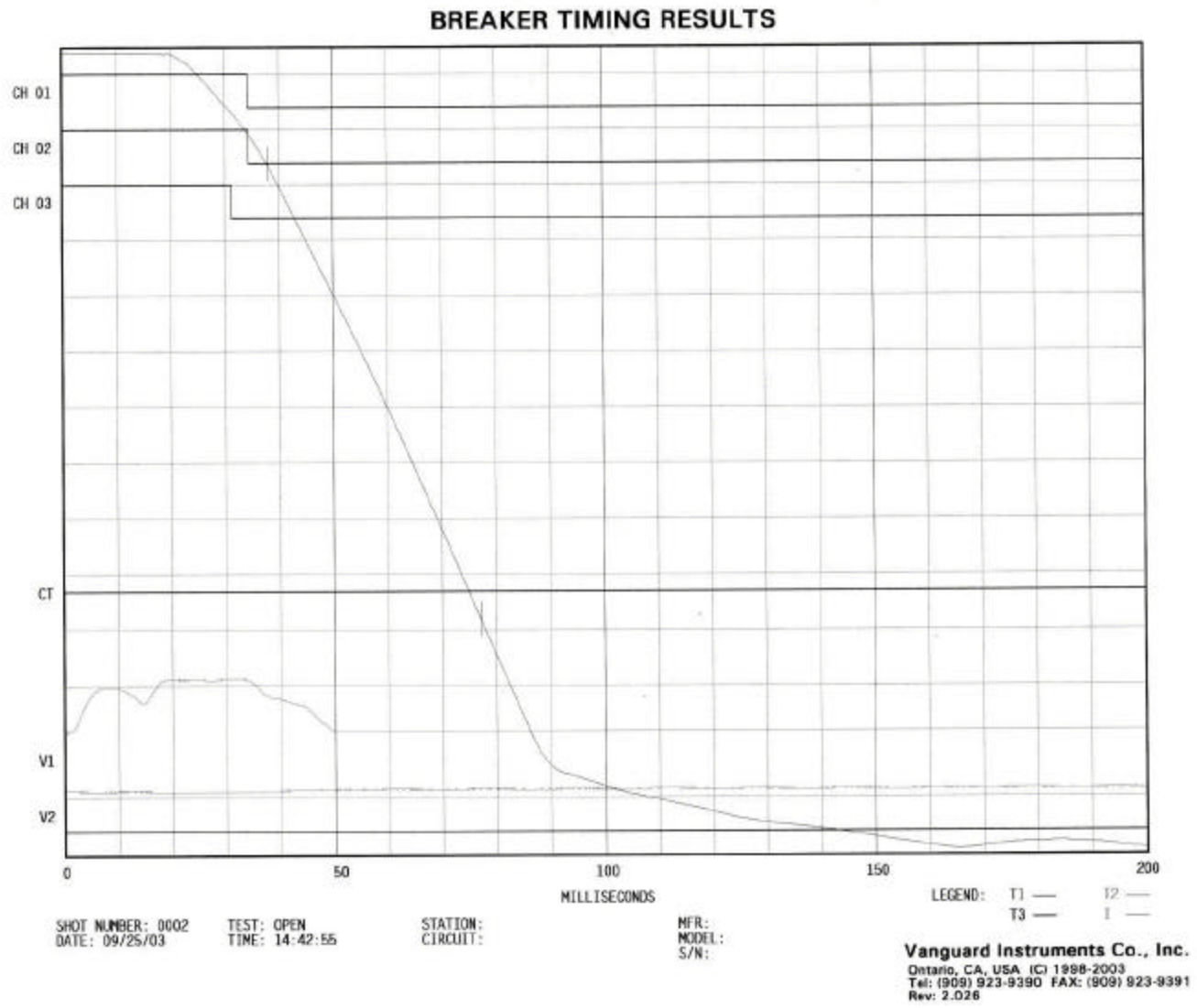


Figure 15.0 Expansion Graph From 0 to 200ms From Ink Jet Printer

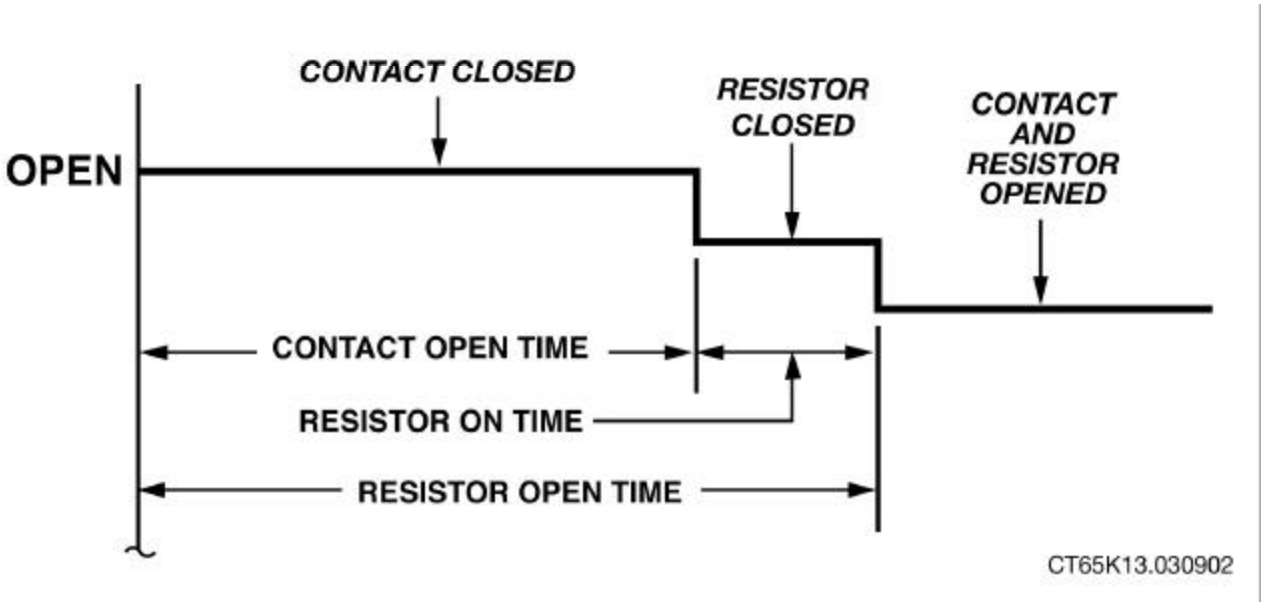


Figure 16.0 Graphical Interpretation of an Open Timing Shot

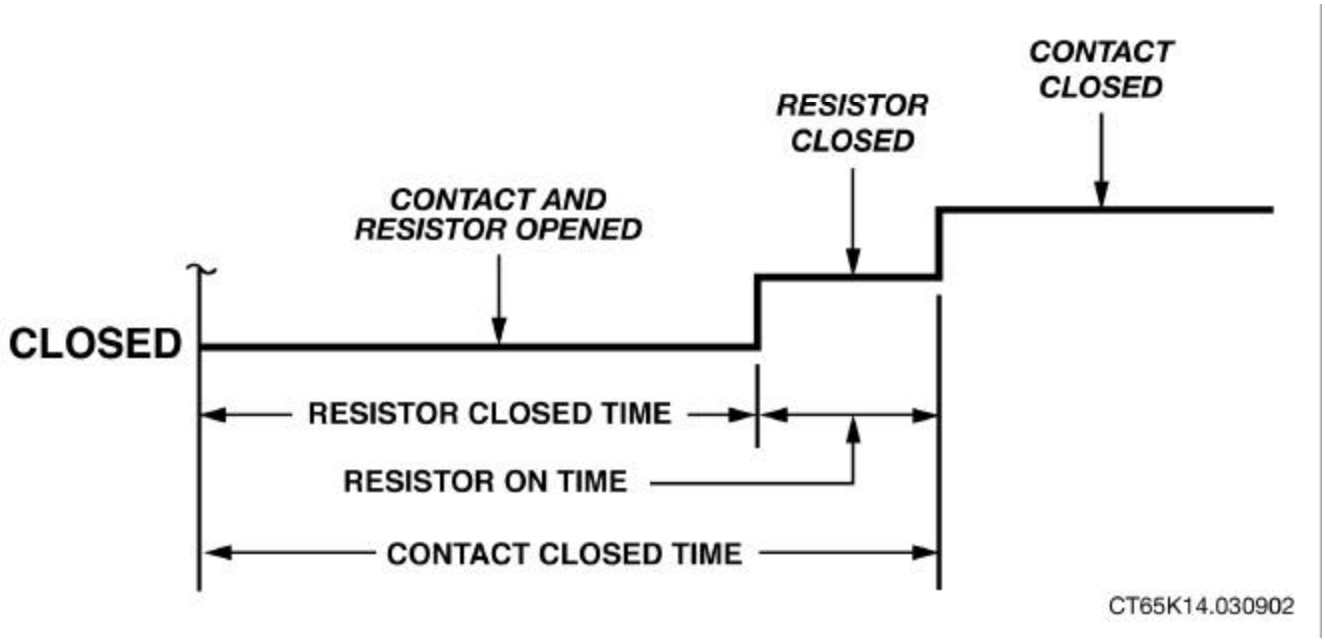


Figure 17.0 Graphical Interpretation of a Close Timing Shot

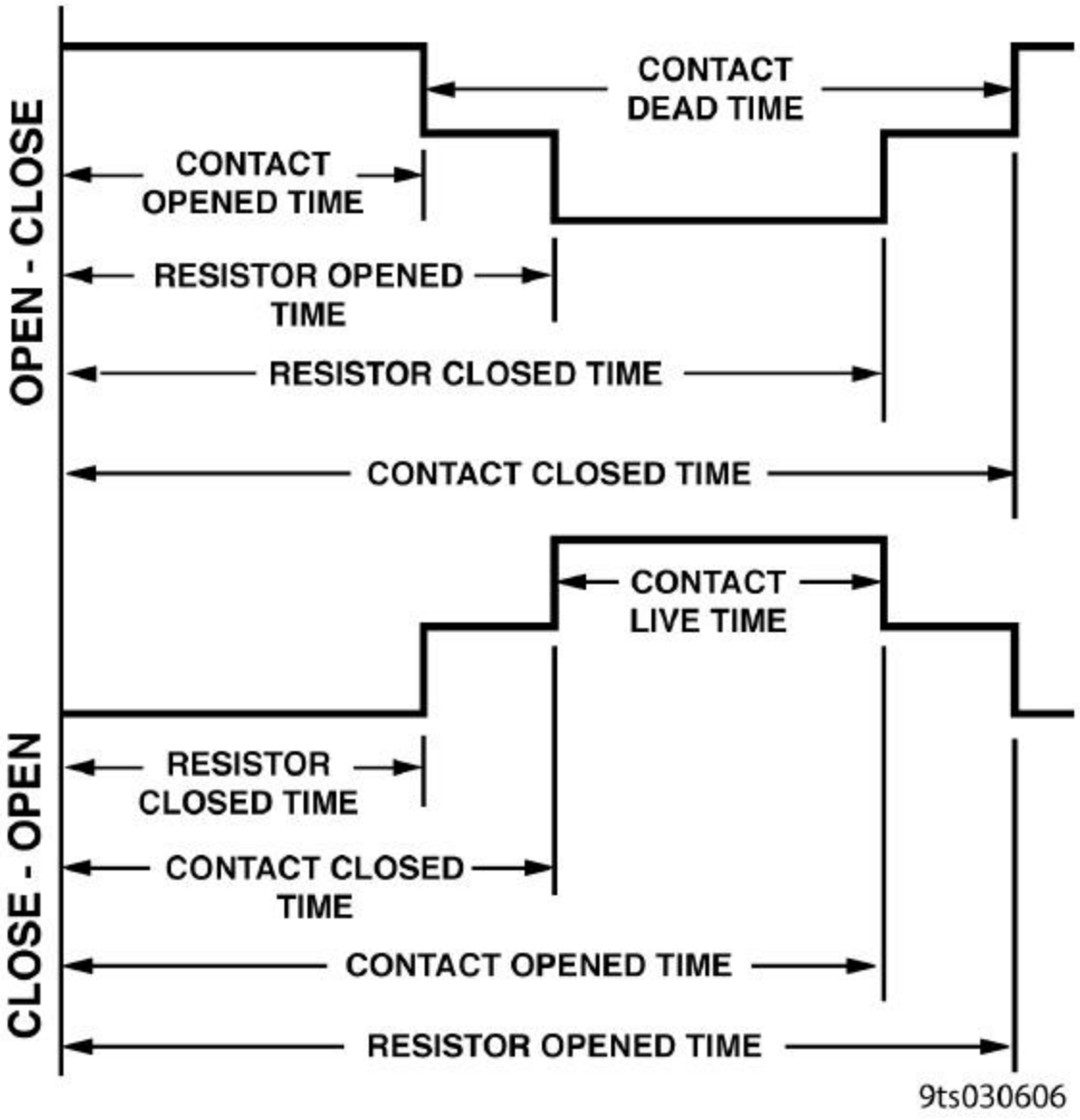


Figure 18.0 Graphical Interpretations of an Open-Close and a Close-Open Timing Shot

9.4 Save Timing Shots in the EEPROM

Use the steps in Table 10.0 to save a timing shot in the FLASH EEPROM.

Table 10.0 Save Timing Shot In EEPROM

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SETUP MENU.	PRESS #3 KEY.	1. ANALYSIS POINTS 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT SAVE MENU.	PRESS #3 KEY.	1. SAVE SHOT 2. RECALL SHOT 3. SHOT DIRECTORY 4. ERASE SHOT
3	SELECT SAVE SHOT.	PRESS #1 KEY.	SAVE SHOT # 002 TEST: CLOSE DATE: 04/23/03 12:36 "ENTER" TO CONFIRM
4	CONFIRM SAVING SHOT.	PRESS THE "ENTER" KEY.	SAVE IN PROCESS PLEASE WAIT
5	OBSERVE SHOT BEING SAVED.	NONE.	SHOT SAVE
6	RETURN TO MAIN MENU.	PRESS ANY KEY.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

NOTE

Timing shot storage capability varies, depending upon the size of the shots. The CT-7000 will assign an identification number for each of the shots stored in the EEPROM.

9.5 Printing Timing Shot Directory Stored in the EEPROM

The user can obtain a timing-shot directory that was stored in the CT-7000's FLASH EEPROM by using the following steps in Table 11.0.

Table 11.0 Print Timing Shot Directory

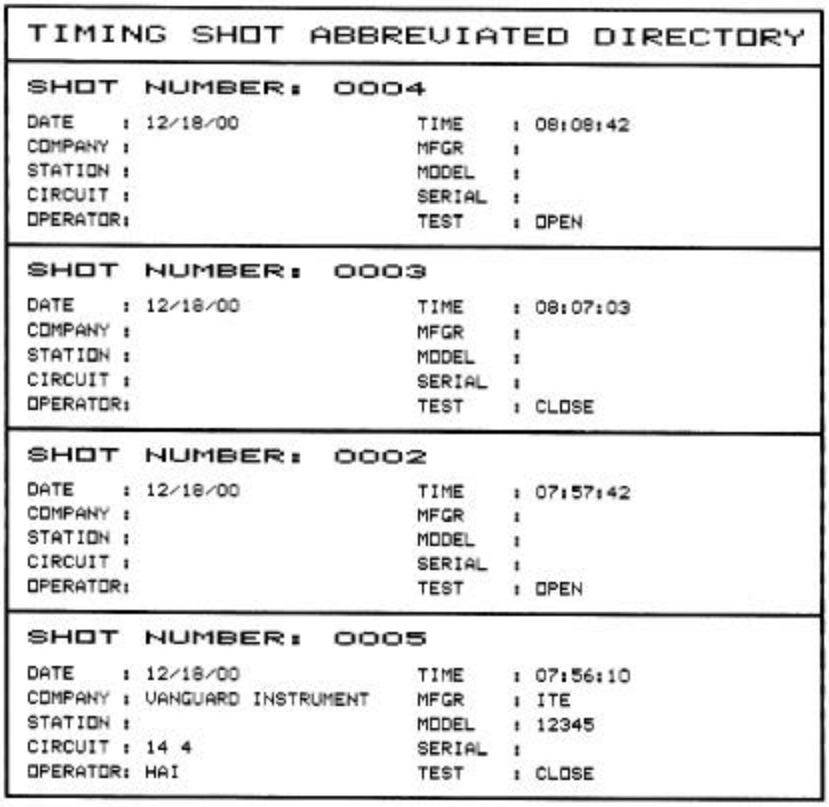
STEP	OPERATION	ACTION	DISPLAY
1	SELECT SETUP MENU.	PRESS #3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT SAVE/RESTORE MENU.	PRESS #3 KEY.	1. SAVE SHOT 2. RESTORE SHOT 3. SHOT DIRECTORY 4. ERASE SHOT
3	SELECT SHORT DIRECTORY.	PRESS # 3 KEY.	1. SHORT DIRECTORY 2. FULL DIRECTORY "STOP" TO QUIT
4	SELECT SHORT DIRECTORY.	PRESS #1 KEY.	PRINTING ABBREVIATED DIRECTORY "STOP" TO QUIT
5	RETURN TO MAIN MENU.	NO ACTION.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

NOTE

1. If the "Short Directory" was selected, the CT-7000 will print out the shot identifications of the last ten timing shots stored in the EEPROM.

2. If the "Full Directory" was selected, the CT-7000 will print out the shot identifications of all the timing shots stored in the EEPROM.

3. A typical shot directory printout is shown on next page, in Figure 19.0.



TIMING SHOT ABBREVIATED DIRECTORY

SHOT NUMBER: 0004

DATE	: 12/18/00	TIME	: 08:08:42
COMPANY	:	MFGR	:
STATION	:	MODEL	:
CIRCUIT	:	SERIAL	:
OPERATOR	:	TEST	: OPEN

SHOT NUMBER: 0003

DATE	: 12/18/00	TIME	: 08:07:03
COMPANY	:	MFGR	:
STATION	:	MODEL	:
CIRCUIT	:	SERIAL	:
OPERATOR	:	TEST	: CLOSE

SHOT NUMBER: 0002

DATE	: 12/18/00	TIME	: 07:57:42
COMPANY	:	MFGR	:
STATION	:	MODEL	:
CIRCUIT	:	SERIAL	:
OPERATOR	:	TEST	: OPEN

SHOT NUMBER: 0005

DATE	: 12/18/00	TIME	: 07:56:10
COMPANY	: VANGUARD INSTRUMENT	MFGR	: ITE
STATION	:	MODEL	: 12345
CIRCUIT	: 14 4	SERIAL	:
OPERATOR	: HAI	TEST	: CLOSE

Figure 19.0 Printout of the Timing Shot Directory From the Thermal Printer

9.6 Recalling a Timing Shot

The following steps in Table 12.0 are used to recall a timing shot stored in the EEPROM to the working memory. Once a timing shot is recalled, the user can ask for a printout of the test results from the thermal printer.

Table 12.0 Recalling a Timing Shot

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SETUP MENU.	PRESS #3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT SAVE/RESTORE SHOT.	PRESS # 3 KEY.	1. SAVE SHOT 2. RESTORE SHOT 3. SHOT DIRECTORY 4. ERASE SHOT
3	SELECT RESTORE SHOT.	PRESS #2 KEY.	ENTER SHOT NUMBER TO BE RESTORED XXXX "ENTER" TO CONFIRM
4	ENTER SHOT NUMBER “1” TO BE RESTORED.	PRESS KEYS 0-9 FOR SHOT ID THEN PRESS THE "ENTER" KEY.	ENTER SHOT NUMBER TO BE RESTORED 0001 "ENTER" TO CONFIRM
5	CONFIRM SHOT TO BE RESTORED.	PRESS THE "ENTER" KEY.	RESTORING SHOT # 0001 TEST: OPEN DATE: 03\12\03 09:12 "ENTER" TO CONFIRM
6	CONFIRM TEST RESTORED.	NONE.	RESTORE COMPLETE
7	RETURN TO MAIN MENU.	PRESS ANY KEY.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTICS

9.7 Deleting a Timing Shot

Users can delete a specific timing shot or all of the timing shots from the CT-7000's EEPROM by using the steps described in Table 13.0.

Table 13.0 Deleting a Timing Shot

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINTS 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT SAVE / RESTORE MENU.	PRESS # 3 KEY.	1. SAVE SHOT 2. RESTORE SHOT 3. SHOT DIRECTORY 4. ERASE SHOT
3	SELECT ERASE SHOT.	PRESS # 4 KEY.	1. ERASE SHOT 2. ERASE ALL SHOTS!
4	SELECT ERASE SHOT.	PRESS # 1 KEY.	ENTER SHOT NUMBER TO BE ERASED XXXX "ENTER" TO CONFIRM
5	ENTER SHOT NUMBER "1" TO BE ERASED.	PRESS KEYS 0-9 TO SELECT SHOT NUMBER, PRESS THE "ENTER" KEY TO CONFIRM.	ERASE SHOT # 0001 TEST: OPEN DATE: 03\12\03 09:12 "ENTER" TO CONFIRM
6	CONFIRM TO ERASE SHOT.	PRESS THE "ENTER" KEY.	ERASE IN PROCESS PLEASE WAIT
7	WAIT FOR SHOT BEING ERASED.	NO ACTION.	ERASE COMPLETE
8	RETURN TO MAIN MENU.	PRESS ANY KEY.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

9.8 Shot Description

The CT-7000 has the capability for users to enter the breaker and other identification information. The data usually consists of the names of the company, station, circuit and manufacturer. Other information could be the breaker's model, serial number and the operator's name. The identification data will print out on the header section of the tabulated report.

If the user saves the timing shot, the identification data will also be saved with the timing shot, along with the time and date.

The user can input letters of the alphabet by utilizing the alphanumeric keys. To select the letter "A," the user will need to press key numbered “2,” twice. To select the letter "C," the user will need to press the key numbered “2,” four times and so on.

To move the cursor forward, press the “UP ARROW” key. To move the cursor backwards, use the “DOWN ARROW” key. Use the “CLEAR” key to enter a space.

Table 14.0 Entering Shot Identification Header

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS #3 KEY.	1. ANALYSIS POINTS 2. MEASUREMENT UNIT 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT NEXT PAGE.	PRESS # 4 KEY.	1. SHOT DESCRIPTION 2. NUMBER OF CHANNELS 3. COMPUTER IF 4. SET CLOCK
3	SELECT SHOT DESCRIPTION.	PRESS # 1 KEY.	ENTER COMPANY NAME XXXXXX "ENTER" TO CONFIRM
4	ENTER COMPANY NAME.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER STATION NAME XXXXXX "ENTER" TO CONFIRM
5	ENTER STATION NAME.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER CIRCUIT NAME XXXXXX "ENTER" TO CONFIRM
6	ENTER CIRCUIT NAME.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER MANUFACTURER NAME XXXXXX "ENTER" TO CONFIRM
7	ENTER MANUFACTURER NAME.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER BREAKER MODEL XXXXXX "ENTER" TO CONFIRM

Table 14.0 Entering Shot Identification Header (Continued)

STEP	OPERATION	ACTION	DISPLAY
8	ENTER BREAKER MODEL.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER SERIAL NUMBER XXXX "ENTER" TO CONFIRM
9	ENTER SERIAL NUMBER.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER SERIAL NUMBER XXXX "ENTER" TO CONFIRM
10	ENTER OPERATOR NAME.	PRESS KEYS 0-9 AND PRESS THE "ENTER" KEY TO CONFIRM.	ENTER OPERATOR NAME XXXX "ENTER" TO CONFIRM
11	RETURN TO MAIN MENU.	NO ACTION.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

9.9 Computer Interface

Each CT-7000 has an RS-232C port, where the Breaker Analysis Software package provided with each CT-7000, enables an IBM-compatible personal computer to communicate with the unit. The software operating under Windows 95, 98, Me, 2000, NT and XP environments allow the user to upload timing shots stored in the EEPROM into the computer. From the user's computer, the user can now reanalyze the breaker's timing shots and then output the timing reports through an office printer. Since timing shots are stored in the office computer, users can create a database of a breaker's timing history.

Follow the steps in Table 15.0 to put the CT-7000 under computer control:

Table 15.0 Selecting or Aborting Computer Control

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT NEXT PAGE.	PRESS # 4 KEY.	1. SHOT DESCRIPTION 2. COMPUTER ITF 3. SET CLOCK 4. SET PRINT MODE
3	SELECT COMPUTER INTERFACE.	PRESS # 2 KEY.	COMPUTER ITF MODE "STOP" TO ABORT

NOTES

1. An interconnect cable must be run between the CT-7000's RS-232C port and an IBM-compatible PC.

2. Refer to the breaker timing software manual to run the unit remotely from an IBM-compatible computer.

3. The CT-7000's RS-232 connector pin layout is in the chart to the right.

4. The operator is required to put the CT-7000 under the "Computer ITF Mode" before executing the PC program.

PIN No.	SIGNAL NAME
2	Tx
3	Rx
5	GND

9.10 Breaker Travel Analysis

The CT-7000's travel analysis includes the breaker's stroke, over-travel, bounce-back, contact-wipe distances and contact velocity calculations.

9.10.1 Breaker Stroke

The CT-7000 uses a digital transducer to measure a breaker's contact stroke, over-travel and bounce-back. The digital transducer output are 200 counts per linear inch of travel, therefore the resolution is accurate to about 1/200 inch. The output resolution is ±0.01 inch on the test result report.

Unlike slide-wire transducers, the CT-7000's transducer needs no calibration or setup. A user verifies the transducer's functionality by selecting a diagnostic test for the transducer, which is further explained in Paragraph 9.19.

9.10.2 Breaker Over-Travel Distance

Over-travel is the distance the contact moves beyond the resting position. Over-travel is typically found in the close operation. (See Appendix A for more details).

9.10.3 Breaker Bounce-Back Distance

Bounce-back is the distance the breaker contact moves before the resting position after the over- travel. Again, bounce-back is typically found in the close operation. (See appendix A for more details).

9.10.4 Contact Wipe

Contact wipe is the distance measured from the close position to the contacts touching or parting positions. In the close operation, contact wipe is measured from the contacts touching position to the final close position.

In the open operation, the contact wipe is measured from the close position to the contact break or parting position.

NOTE

Contact wipe is measured during an operation. The measurement may not be as accurate as the measurement done using the Slow-Close Mode. It is recommended that the user use the Slow-Close Test to verify the contact wipe measurement, if required. Please refer to Paragraph 9.18 for further information on the Slow-Close Mode.

9.10.5 Breaker Velocity

When used with a travel transducer, the CT-7000 can calculate the breaker contact velocity through the arc zone. Users will need to program the calculation points or analysis points on the travel curve for the unit to calculate the contact velocity. Analysis point selections and setup are discussed in the following paragraphs.

9.10.6 Analysis Point Selections

Analysis points are used to calculate the average contact speed through the contact's arc zone. The analysis points are usually specified by the breaker's manufacturers. The analysis points can programmed into the CT-7000 by the user. The CT-7000 will store the two setup points for calculating velocity one set each for the open and another set for the close operations. These setups remain in the CT-7000's memory until it is changed by the user.

9.10.7 Analysis Point No.1 (AP1)

Three selections are available to the user for setting analysis point No. 1:

1. PERCENTAGE OF STRK
2. DISTANCE FROM CLOSE
3. CONTACT #1

a. Percentage of Stroke

Percentage of stroke is the distance based upon the percentage of the total breaker's stroke distance. ***The distance is always measured from the starting point at the fully closed position of the breaker contacts***. See appendix A for more detail.

b. Distance From Close

Distance from Close range is selectable from 00.0 inch to 99.99 inches or from 0.0 centimeter to 99.90 centimeters. ***Again, the distance is referenced from the contact's closed position.*** See Appendix A for more detail.

c. Contact Point #1

Contact point is the distance from the contact's closed position to the point where it is in transition from the close-to-open or the open-to-close position. ***Contact channel #1 will be used for the selection.***

9.10.8 Analysis Point No. 2 (AP2)

There are three selections for analysis point 2:

1. PERCENTAGE OF STRK
2. DISTANCE FROM CLOSE
3. CONTACT +/- TIME

a. See Paragraph 9.10.7.a for "PERCENTAGE OF STROKE" description.

b. See Paragraph 9.10.7.b for "DISTANCE FROM CLOSE" description.

c. "CONTACT +/- TIME", is available for both OPEN and CLOSE operation under analysis point #2 only. For "CONTACT + TIME", the user enters the millisecond time after the contact channel #1 made the transition from OPEN to CLOSE or CLOSE to OPEN to define the Analysis Point No. 2.
For "CONTACT – TIME", the user enters the millisecond time before the contact channel #1 makes the transition from OPEN to CLOSE or CLOSE to OPEN to define the Analysis Point No. 2.

NOTES

1. Average velocity through the arc zone is calculated by using the following formula:

$$V_{ave} = \text{Distance} \div \text{Time}$$

2. The breaker contact velocity can be recalculated based upon the data stored inside the memory after any new analysis points were selected. The user does ***not*** need to operate the breaker again to acquire new contact velocity data after changing the analysis points because the new velocity is then calculated from the travel data stored in memory from the last operation.

3. For complex velocity calculations, the user can create a test plan using the CT-7000 Breaker Analysis Software from a PC. The test plan then can be downloaded to the CT-7000. The complex breaker velocity calculation can now be executed easily by recalling the test plan before running the timing test.

9.11 Set-Up Open Analysis Points

Table 16.0 Setting Up "OPEN" Analysis Points Using Distance

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT ANALYSIS POINT.	PRESS # 1 KEY.	1. OPEN TIMING 2. CLOSE TIMING 3. PRINT SETTING 4. TEST PLAN
3	SELECT OPEN TIMING.	PRESS # 1 KEY.	OPEN ANALYSIS PT 1 1. PERCENT OF STROKE 2. DISTANCE FROM CLOSE 3. CONTACT #1
4	SELECT DISTANCE FROM CLOSE.	PRESS # 2 KEY.	OPEN ANALYSIS PT 1 DISTANCE FROM CLOSE VALUE: XX.XX in "ENTER" TO CONFIRM
5	ENTER 1 INCH.	PRESS KEYS 0-9 TO SET 1.00. USE THE “ENTER” KEY TO CONFIRM.	OPEN ANALYSIS PT 1 DISTANCE FROM CLOSE VALUE: 01.00 in "ENTER" TO CONFIRM
6	CONFIRM ENTRY.	PRESS THE "ENTER" KEY.	OPEN ANALYSIS PT 2 1. PERCENTAGE OF STROKE 2. DISTANCE FROM CLOSE 3.CONTACT +/- TIME
7	SELECT DISTANCE FROM CLOSE.	PRESS # 2 KEY.	OPEN ANALYSIS PT 2 DISTANCE FROM CLOSE VALUE: XX.XX in "ENTER" TO CONFIRM
8	ENTER 2 INCHES.	PRESS KEYS 0-9 TO SET 2.00 INCHES.	OPEN ANALYSIS PT 2 DISTANCE FROM CLOSE VALUE: 02.00 in "ENTER" TO CONFIRM
9	RETURN TO MAIN MENU.	PRESS THE "ENTER" KEY.	1.TIME BRKR 2.GET RSLT 3.SET UP 4.DIAGNOSTICS

NOTES

1. If an entry is not correct, re-enter the digits until the screen shows the desired numbers, then press the “ENTER” key.

2. Analysis Point #1 is 1.00 inch from the fully closed position.

3. Analysis Point #2 is 2.00 inches from the fully closed position.

9.12 Circuit Breaker Test Plan

A circuit breaker test plan contains breaker maximum/minimum operating parameters. A typical list of operating parameters is show as follows:

- Max/Min Contact/Resistor Trip Time.
- Max/Min Contact/Resistor Close Time.
- Max Contact Spread Time.
- Max Resistor Contact Spread Time.
- Max/min Contact Close-Open Time.
- Max/min Contact Open-Close Time.
- Max/min Resistor Close-Open Time.
- Max/min Resistor Open-Close Time.
- Max/Min Breaker Stroke.
- Max/Min Breaker Trip Velocity.
- Max/Min Breaker Close Velocity.
- Max/Min Breaker Over Travel.
- Max/Min Breaker Bounce Back.
- Trip Velocity Analysis Calculation Points.
- Close Velocity Analysis Calculation Points.

The user can create a circuit breaker test plan using the CT-7000 Breaker Analysis Software. Up to 99 circuit breaker test plan can be downloaded into the CT-7000. A test plan can be replaced by simply downloading a new test plan into the existing one.

If a timing test is executed with a breaker test plan, the timing report will also display a Pass/Fail status for each of the parameters tested.

9.13 Recall a Breaker Test Plan

Recalling a test plan allows the user to bring the breaker Pass/Fail parameters or operating limits to memory. Since the breaker test plan contains analysis points and any velocity calculation formula, there is no setting required for the CT-7000.

After recalling the breaker test plan, the user can immediately test circuit breaker and view timing report.

Table 17.0 Recalling a Test Plan

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT ANALYSIS POINT.	PRESS # 1 KEY.	1. OPEN TIMING 2. CLOSE TIMING 3. PRINT SETTING 4. TEST PLAN
3	SELECT TEST PLAN.	PRESS # 4 KEY.	1. LOAD TEST PLAN 2. PRINT TEST PLAN 3. PRINT DIRECTORY

STEP	OPERATION	ACTION	DISPLAY
4	SELECT LOAD TEST PLAN.	PRESS # 1 KEY.	LOAD TEST PLAN “Ù” “Ú” TO SCROLL "ENTER" TO SELECT
5	VIEW TEST PLAN HEADER.	PRESS “UP” or “DOWN” KEY TO SCROLL.	DISPLAY TEST PLAN HEADER
6	CONFIRM TEST PLAN TO BE LOADED.	PRESS THE "ENTER" KEY.	1.TIME BRKR 2.GET RSLT 3.SET UP 4.DIAGNOSTICS

```
BREAKER TIMING RESULTS - 60 Hz

          SHOT NUMBER: 0006
DATE: 09/01/03    TIME: 13:17:17

COMPANY:   VANGUARD INSTRUMENT
STATION:
CIRCUIT:
MFR:          ITE
MODEL:        14 4k
S/N:
OPERATOR:

TEST: OPEN

CONTACT TIME
CH   TIME   CYCLE P/F   BOUNCE   WIPE
     (mS)                (mS)    (in)
 1 034.20 02.05 PASS000.20 00.72
 2 034.40 02.06 PASS000.10 00.73
 3 031.10 01.87 PASS000.20 00.52
DELTA TIME (mS): 003.30 PASS

TRAVEL ANALYSIS   T1    P/F
STROKE       in   07.01 PASS
SPEED      ft/S   08.53 FAIL
OVER-TRAVEL in   00.02 PASS
BOUNCE BACK in   00.05 PASS

SPEED ANALYSIS:
POINT 1 = 01.00 in
POINT 2 = 05.00 in

U1 NOMINAL VOLTAGE = 47 VOLTS
U1 MINIMUM VOLTAGE = 47 VOLTS
INITIATOR CURRENT  = 05.7 AMPS

SHOT LENGTH:            1 SECOND
INSERTION RESISTOR:     NO
TRIGGER:                INTERNAL
```

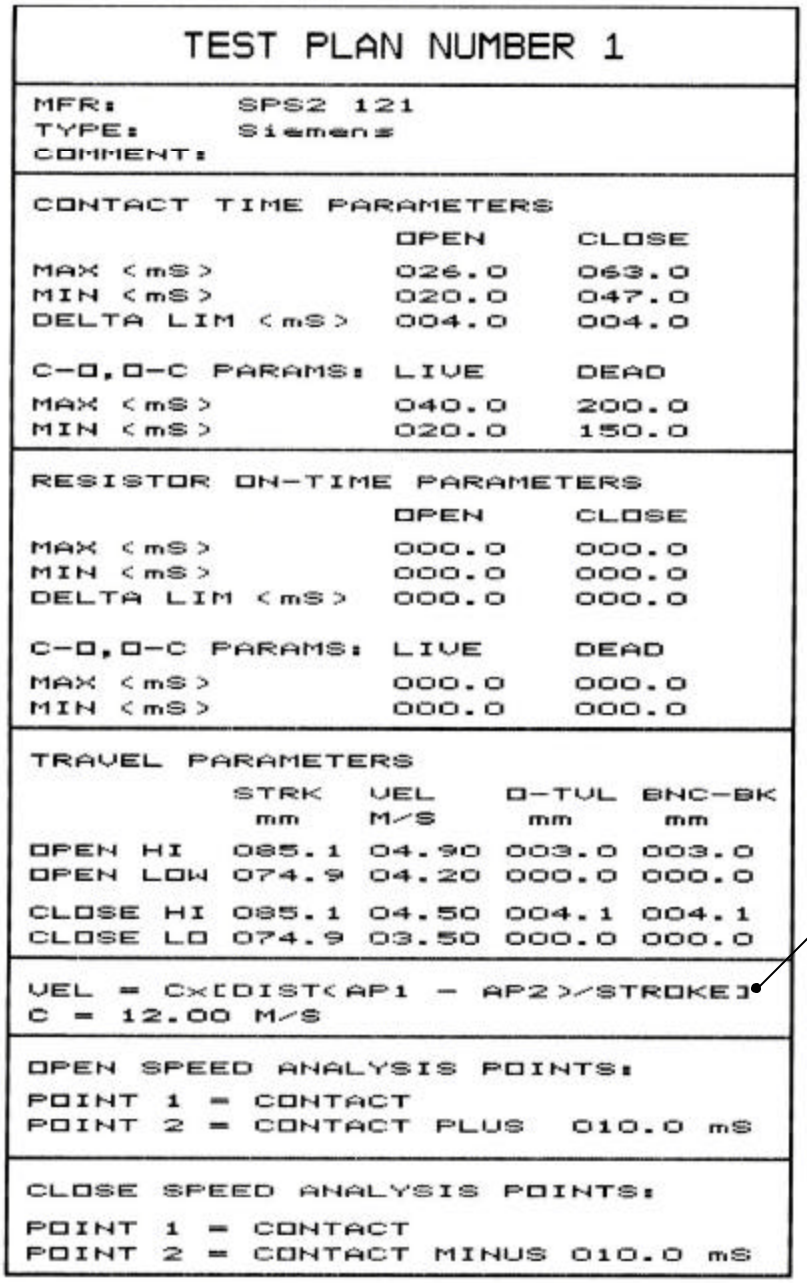
Figure 20.0 Typical Test Results With Pass/Fail Printout

9.14 Print a Breaker Test Plan

The user can print a breaker test plan stored in the CT-7000 EEPROM.

Table 18.0 Print a Test Plan

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT ANALYSIS POINT.	PRESS # 1 KEY.	1. OPEN TIMING 2. CLOSE TIMING 3. PRINT SETTING 4. TEST PLAN
3	SELECT TEST PLAN.	PRESS # 4 KEY.	1. LOAD TEST PLAN 2. PRINT TEST PLAN 3. PRINT DIRECTORY
4	SELECT PRINT TEST PLAN.	PRESS # 2 KEY.	LOAD TEST PLAN “Ù” “Ú” TO SCROLL "ENTER" TO SELECT
5	VIEW TEST PLAN HEADER.	PRESS “UP” or “DOWN” KEY TO SCROLL.	DISPLAY TEST PLAN HEADER
6	CONFIRM TEST PLAN TO BE PRINTED.	PRESS THE "ENTER" KEY.	1.TIME BRKR 2.GET RSLT 3.SET UP 4.DIAGNOSTICS



TEST PLAN NUMBER 1

MFR: SPS2 121
TYPE: Siemens
COMMENT:

CONTACT TIME PARAMETERS

	OPEN	CLOSE
MAX <mS>	026.0	063.0
MIN <mS>	020.0	047.0
DELTA LIM <mS>	004.0	004.0
C-O,O-C PARAMS:	LIVE	DEAD
MAX <mS>	040.0	200.0
MIN <mS>	020.0	150.0

RESISTOR ON-TIME PARAMETERS

	OPEN	CLOSE
MAX <mS>	000.0	000.0
MIN <mS>	000.0	000.0
DELTA LIM <mS>	000.0	000.0
C-O,O-C PARAMS:	LIVE	DEAD
MAX <mS>	000.0	000.0
MIN <mS>	000.0	000.0

TRAVEL PARAMETERS

	STRK mm	VEL M/S	O-TVL mm	BNC-BK mm
OPEN HI	085.1	04.90	003.0	003.0
OPEN LOW	074.9	04.20	000.0	000.0
CLOSE HI	085.1	04.50	004.1	004.1
CLOSE LO	074.9	03.50	000.0	000.0

VEL = C×[DIST<AP1 - AP2>/STROKE]
C = 12.00 M/S

OPEN SPEED ANALYSIS POINTS:
POINT 1 = CONTACT
POINT 2 = CONTACT PLUS 010.0 mS

CLOSE SPEED ANALYSIS POINTS:
POINT 1 = CONTACT
POINT 2 = CONTACT MINUS 010.0 mS

Velocity Calculation Formula

Figure 21.0 Typical Test Plan Printout of a Siemens SPS2 on Thermal Printer

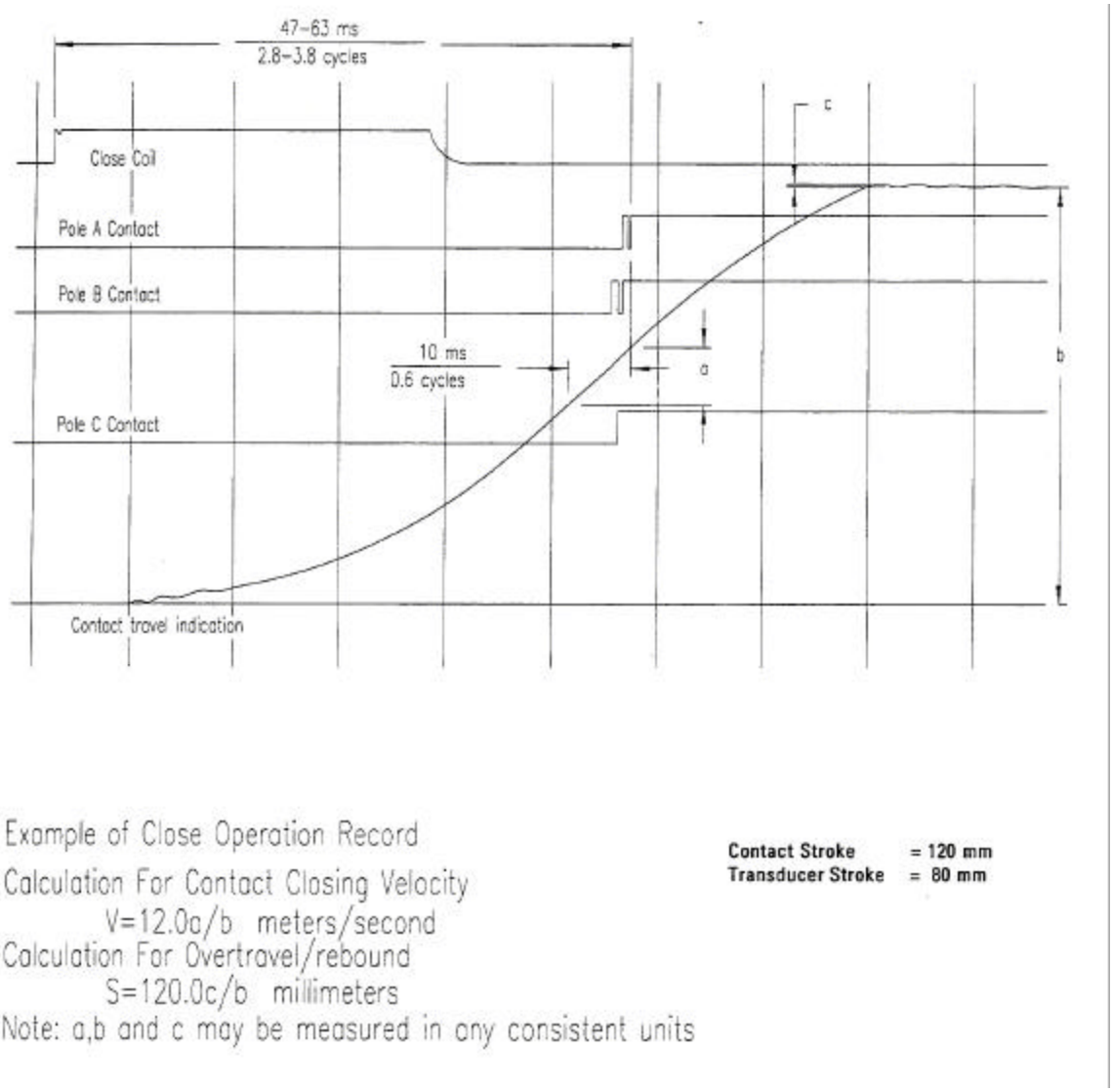
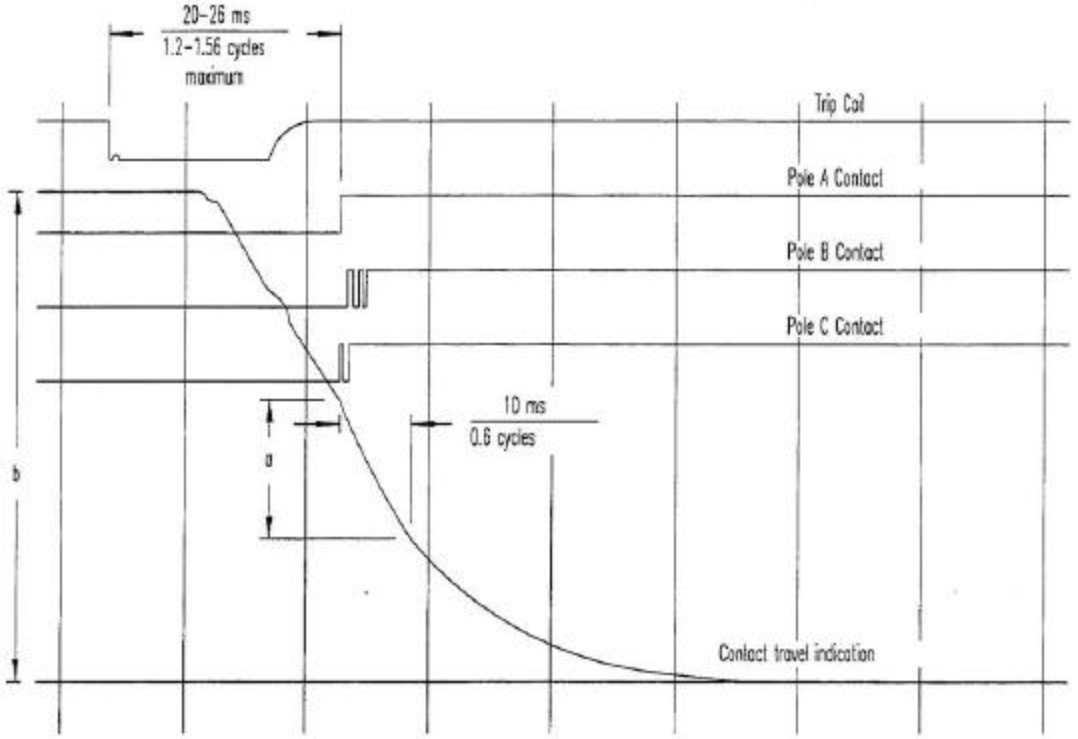


Figure 22.0 Siemens SPS2 121 Close Timing Illustration



Example of Opening Operation Record

Calculation For Contact Opening Velocity
V=12.0a/b meter/second

Note: a,b and may be measured in any consistant units

Contact Stroke = 120mm
Transducer Stroke = 80 mm

Figure 23.0 Siemens SPS2 121 Open Timing Illustration

9.15 Print a Breaker Test Plan Directory

The CT-7000 breaker test plan directory stored in the CT-7000 EEPROM using the steps in table below:

Table 19.0 Print a Breaker Test Plan Directory

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT ANALYSIS POINT.	PRESS # 1 KEY.	1. OPEN TIMING 2. CLOSE TIMING 3. PRINT SETTING 4. TEST PLAN
3	SELECT TEST PLAN.	PRESS # 4 KEY.	1. LOAD TEST PLAN 2. PRINT TEST PLAN 3. PRINT DIRECTORY
4	SELECT PRINT DIRECTORY.	PRESS # 3 KEY.	1.TIME BRKR 2.GET RSLT 3.SET UP 4.DIAGNOSTIC

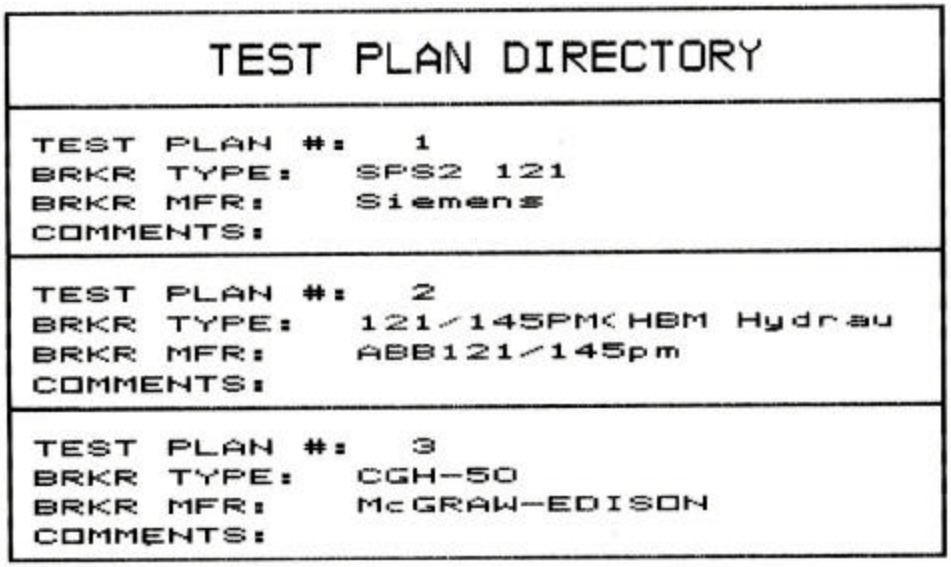


Figure 24.0 Typical Test Plan Directory Print Out.

9.16 English/Metric or Rotary Transducer Selection

The CT-7000 supports and displays both English and Metric calculations from the breaker's travel parameters such as the stroke, velocity and other parameters. The user can switch from one system to the other by following the steps in Table 20.0. Rotary transducer requires the user to enter the defined linear distance in millimeters or inches, per one degree of rotary motion as seen in Table 21.

Table 20.0 Select Metric Units of Measure

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT MEASUREMENT UNITS.	PRESS # 2 KEY.	SELECT UNITS 1. ENGLISH 2. METRIC 3. ROTARY TRANSDUCER
3	SELECT METRIC.	PRESS # 2 KEY.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

Table 21.0 Select Rotary Transducer

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT MEASUREMENT UNITS.	PRESS # 2 KEY.	SELECT UNITS 1. ENGLISH 2. METRIC 3. ROTARY TRANSDUCER
3	SELECT ROTARY TRANSDUCER.	PRESS # 3 KEY.	ROTARY ENCODER: 1. ENGLISH (In./deg) 2. METRIC (MM/deg)
4	SELECT INCH PER DEGREE.	PRESS #1 KEY.	INCHES/DEGREE 0.014 in/deg
5	ENTER 0.50 INCH PER DEGREE.	ENTER 0.50 USING 0-9 KEYS.	INCHES/DEGREE 0.500 in/deg
6	RETURN TO MAIN MENU.	PRESS THE “ENTER” KEY.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

9.17 Set CT-7000 Internal Clock

The CT-7000 has an internal clock with a lithium battery. The clock's time and date is displayed on the LCD screen. When a timing shot is stored in the EEPROM, the time and date are also stored along with the shot. To set the clock, perform the steps in the following Table 22.0.

Table 22.0 Setting the Clock and Calendar

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT NEXT PAGE.	PRESS # 4 KEY.	1. SHOT DESCRIPTION 2. COMPUTER ITF 3. SET CLOCK 4.SET PRINT MODE
3	SELECT SET CLOCK.	PRESS # 3 KEY.	TIME: HH:MM:00 XX:YY:00
4	ENTER HOURS AND MINUTES.	PRESS KEYS 0-9.	TIME: HH:MM:00 XX:YY:00 DATE: MM/DD/YY XX/YY/ZZ
5	ENTER MONTH, DATE, YEAR.	PRESS KEYS 0-9.	TIME: HH:MM:00 XX:YY:00 DATE: MM/DD/YY XX/YY/ZZ
6	RETURN TO MAIN MENU.	NO ACTION.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

NOTE

1. The clock battery is good for three years.

2. Loosing the clock battery will not affect the CT-7000’s performance.

9.18 Slow-Close Test

The CT-7000 offers a unique feature called a "Slow-Close" test. The test permits users to measure the distance of a breaker's contact travel from the fully opened position to the contact or "touch" position, to the contact wipe, or penetration distance. The test requires the operator to manually jack the breaker's contact from the fully open position to the fully closed position.

Contact channel 1, 2, 3 and the transducer channel 1 will be used for “Slow-Close” test. The CT-7000 will measure the contact touch and contact wipe for each contact channel.

Contact touch is the distance measured from the contact fully opened to the first position where the contact channel is electrically closed.

Contact wipe, or penetration, is the distance measured from the contact position first, electrically closed to the final closed, latching position.

Table 23.0 Performing a Slow-Close Test

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC MENU.	PRESS # 4 KEY.	1. SLOW CLOSE TEST 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOK UP
2	SELECT SLOW CLOSE TEST.	PRESS # 1 KEY.	BREAKER SLOW CLOSE TEST RMV CB GND (1 SIDE) "ENTER" TO BEGIN
3	START SLOW CLOSE TEST.	PRESS THE "ENTER" KEY.	CONTACT 1:OPEN CONTACT 2:OPEN CONTACT 3:OPEN LIFT TO CLS BREAKER NOW
4	CONTINUE TO CLOSE BREAKER.	NO ACTION.	LIFT BRKR TO CLS POS THEN PRESS "ENTER" TO FIND CONTACT WIPE
5	RETURN TO MAIN MENU.	NO ACTION.	1. TIME BRKR 2. GET RSLT 3. SET UP 4. DIAGNOSTIC

NOTE

The user can also save a Slow-Close test report in the EEPROM. A typical report of a Slow-Close test is shown on the next page in Figure 25.0.

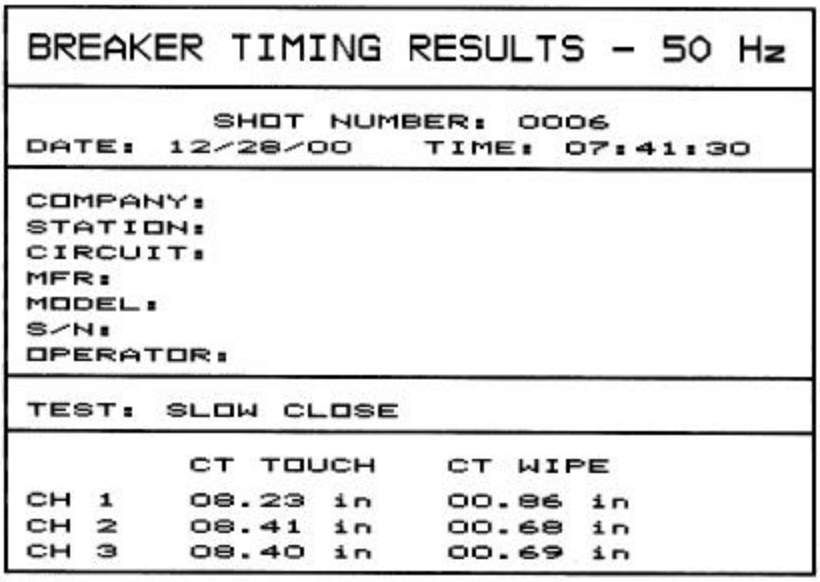


Figure 25.0 Typical Slow-Close Test Report

NOTE

By adding the contact touch and the contact wipe distance, the total is the breaker' stroke.

9.19 Transducer Self-Test

The operator can check the transducer electronics by connecting the transducer to the CT-7000 and running a "Test Transducer" diagnostics.

Table 24.0 Performing a Transducer Self Test

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC.	PRESS # 4 KEY.	1. SLOW-CLOSE TEST 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOKUP
2	SELECT TRANSDUCER.	PRESS # 3 KEY.	TRANSDUCER TEST 1= XXX.XX INCHES 2= XXX.XX INCHES 3= XXX.XX INCHES

NOTES

1. After selecting the transducer test mode, move the transducer slider and observe the display on the CT-7000 LCD.

2. If the slider is moved 1.00 inch, the CT-7000 LCD should display 1.00 inch.

3. Press the "STOP" key to return back to the main menu.

9.20 Check Cable Hookup

Table 25.0 Checking the Cable Hookup

STEP	OPERATION	ACTION	DISPLAY
1	SELECT DIAGNOSTIC.	PRESS # 4 KEY.	1. SLOW-CLOSE TEST 2. PRINT DATA 3. TEST TRANSDUCER 4. CHECK HOOKUP
2	SELECT CHECK HOOK UP.	PRESS # 4 KEY.	MAKE SURE BREAKER IS IN CLOSE POSITION, THEN PRESS "START"
3	INITIATE TEST.	PRESS THE "START" KEY.	1 2 3 C - - -
4	RETURN TO MAIN MENU.	PRESS THE "STOP" KEY.	1. TIME BREAKER 2. GET RESULT 3. SET UP 4. DIAGNOSTIC

NOTES

1. The CT-7000 will also print the test report with the thermal printer.
2. A contact closure is shown as "C" on the LCD and printout.
3. An open contact is shown as "-" on the LCD and printout.

9.21 Automatic Print Setting

The CT-7000 can be set to print graphs and tabulated results automatically after each timing shot. To turn on the "Auto Print Results" mode, follow the steps in Table 26.0.

Table 26.0 Automatic Print Setting

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT NEXT PAGE.	PRESS # 4 KEY.	1. SHOT DESCRIPTION 2. COMPUTER ITF 3. SET CLOCK 4. SET PRINT MODE
3	SELECT SET PRINT.	PRESS # 4 KEY.	SET PRINT MODE 1. AUTOMATIC PRINT 2. BY REQUEST ONLY
4	SELECT "AUTOMATIC PRINT".	PRESS # 1 KEY.	1. TIME BREAKER 2. GET RESULT 3. SET UP 4. DIAGNOSTIC

NOTE

Select print "BY REQUEST ONLY" will disable the "Automatic Print" mode.

9.22 CT-7000 Channel Configuration

The CT-7000 is available with 3-, 6-, or 12- contact inputs. Under most common timing conditions, the user needs to use only 3 contact timing channels and one travel transducer. There is no need to print more than 3 timing channels and one transducer channel on the graphic and tabulated report. The CT-7000 will always default to 3 contact channels (channel 1, 2 and 3) and one transducer channel (transducer channel #1) when the user first turns on the unit. The user can always turn on the rest of the timing channels and transducer channels by following the steps shown in the table below:

Table 27.0 Channel Configuration

STEP	OPERATION	ACTION	DISPLAY
1	SELECT SET UP MENU.	PRESS # 3 KEY.	1. ANALYSIS POINT 2. MEASUREMENT UNITS 3. SAVE / RESTORE 4. NEXT PAGE
2	SELECT NEXT PAGE.	PRESS # 4 KEY.	1. SHOT DESCRIPTION 2. NUMBER OF CHANNELS 3. COMPUTER ITF 4. SET CLOCK 5. PRINT MODE
3	SELECT NUMBER OF CHANNELS.	PRESS # 2 KEY.	NUMBER OF CHANNELS 1. 3 CONTACT 2. 6 CONTACT 3. 12 CONTACT
4	SELECT 3 CHANNELS OR 6 CHANNELS OR 12 CHANNELS.	PRESS # 1, OR 2 OR 3 KEY.	1. TRANSDUCER 1 2. TRANSDUCER 1 & 2 3. TRANSDUCER 1 & 2 & 3
5	SELECT 1 TRANSDUCER, OR 2, OR 3.	PRESS #1, OR #2, OR #3.	1. TIME BREAKER 2. GET RESULT 3. SET UP 4. DIAGNOSTIC

9.23 Running CT-7000 in Tandem

For timing application requiring more than 12 timing contact channels, the user can use two or more CT-7000s to time a circuit breaker. A typical application is to use a CT-7000-12 and a CT-7000-6 to time a 18-contact ATB. To time this circuit breaker, the user can use the following steps:

- Connect the CT-7000-12 to phase A and B of the circuit breaker.
- Connect the CT-7000-6 to phase C of the circuit breaker.
- Connect the CT-7000-12 initiate cable to the breaker control circuit. This CT-7000-12 will operate the circuit breaker.
- Connect the CT-7000-6 external trigger cable to the OPEN coil for the OPEN test and CLOSE coil for the CLOSE test. This CT-7000-6 will operate as a slave device.
- Set the CT-7000-6 to start a test using “EXTERNAL TRIGGER”.
- Set the CT-7000-12 to start a test using “INTERNAL TRIGGER”.
- Press “START” key on the CT-7000-6 to start the sequence the press the “START” key and hold the “ARM” switch on the CT-7000-12.

The CT-7000-12 will operate the circuit breaker and start the timing sequence. The CT-7000-6 will start its timing sequence as soon as it senses the voltage applied to the breaker coil.

The timing report of the CT-7000-12 will show the contact time of phase A and B. The timing report of the CT-7000-6 shows contact time for phase C.

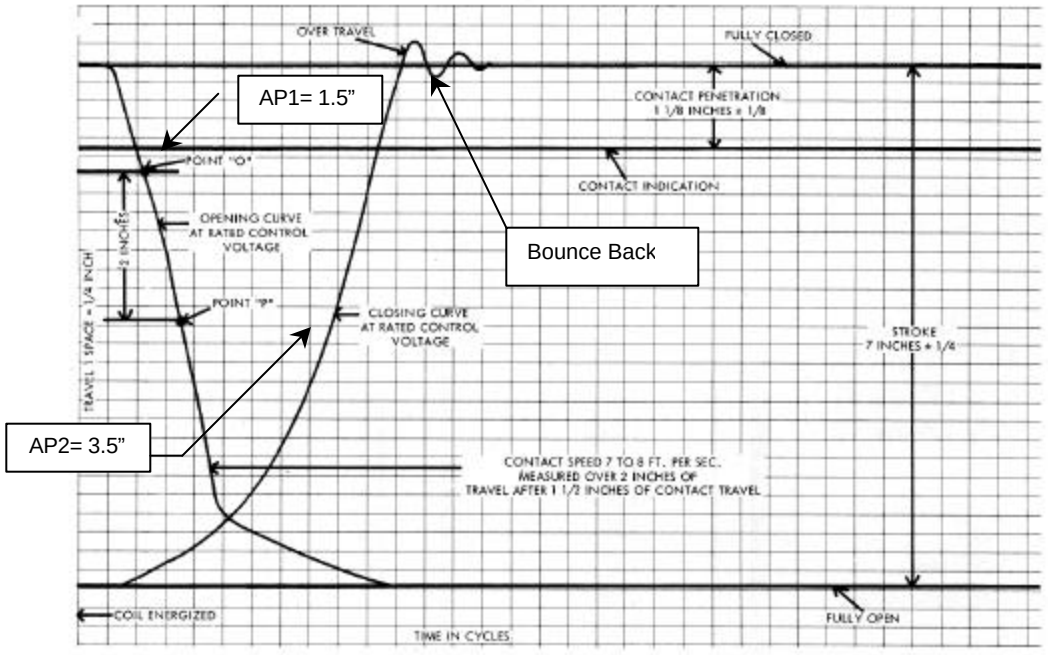
If the user downloads the test results of both the CT-7000s to the PC, the user then can combine the 2 test reports to generate a 18 channel test report. This report now can be printed on the PC printer.

10.0 CT-7000 Trouble Shooting Guide

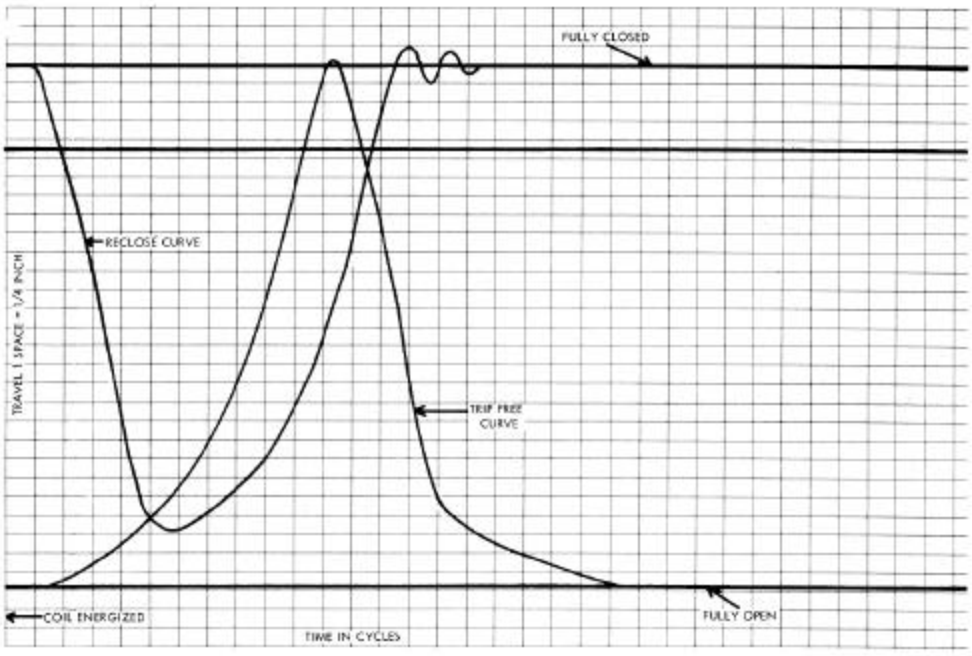
Problems	Suggestion
1. CT-7000 will not trip nor close the breaker.	■ Make sure you hold the “ARM” switch down during each test. ■ Check the OPEN or CLOSE fuses. ■ Check the initiate leads. For a “Positive Trip” circuit, one Close lead and one Open lead should be connected to the Positive side of the power supply. ■ Check the initiate leads. For a “Negative Trip” circuit, one Close lead and one Open lead should be connected to the Negative side of the power supply.
2. Getting message “TRIGGER FAULT” “No Trigger” When using external trigger.	■ Trigger voltage was not detected by the CT-7000. ■ Check the external trigger input to the CT-7000. ■ Make sure the external trigger signal is presented when the CT-7000 displays “AWAITING TRIGGER.”
3. Missing timing or transducer channels on report and graphic output.	■ Timing or transducer channels were not turned on. Turn on channels by going to “SETUP”, “NEXT PAGE”, “NUMBER OF CHANNELS”.
4. No contact time (0 ms) in Trip or Close test.	■ Make sure one side of the breaker in not grounded. ■ Make sure the breaker operates on the Open or Close test only. A dual operation OPEN-CLOSE or CLOSE-OPEN will result in 0 ms reading. ■ Damaged CT-7000 contact channels or bad cables. Try the “CHECK HOOK-UP” test.
5. No contact time (0 ms) in Close-Open.	■ Make sure the breaker contacts complete the transition from the Open (initial state) to the Close, then to the Open (final state). You can see The transition by looking at the timing chart. ■ Make sure the contact close state is longer than 10 ms. The CT-7000 has a 10ms de-bounce time, any contact state less than or equal to 10ms is invalid, thus the delay time is probably too slow. ■ Try the Close-Open using contact channel #1 option.
6. Select Open-Close test. The breaker opens and will not close.	■ Delay between Open to Close is probably too small. Increase delay time.
7. No data or erratic reading on travel transducer.	■ Bad transducer. Try “TEST TRANSDUCER” diagnostics. ■ Transducer slider is not secured to timing rod. ■ Transducer is not secured properly.
8. No activity on” V2” voltage input channel.	■ The “V2” voltage input channel requires a voltage change from 0 V to above 30 V, to see activities on the timing chart.

Problems	Suggestion
9. How does one review the current analysis setting?	■ Go to SETUP (Press key #3). ■ Select Analysis (Press key #1). ■ Select PRINT SETTING (Press key #3). The CT-7000 will print out the current AP1 & AP2 settings.
10. The CT-7000 will not communicate with the PC.	■ Make sure the CT-7000 is under computer control mode. ■ Make sure your PC communication port is selected correctly. ■ Make sure your serial cable is connected properly.
11. Turn on Automatic Print Results mode.	■ See section 9.21.
12. Where can one get some thermal paper?	■ Call the factory at 909-923-9390 or BG Instruments at 509-893-9881. The CT-7000 uses TP-4 thermal paper. ■ In case of an emergency, thermal paper can be purchased at Radio Shack. Radio Shack carries 4.25 inch wide thermal paper. It is not the right size but it will work.
13. How does one darken or lighten the LCD?	■ Press and hold the "↑ PAPER LCD" key will darken the LCD. ■ Press and hold the "↓ PAPER LCD" key will lighten the LCD.
14. How does one move thermal paper forward or backward?	■ Press and release the "↑ PAPER LCD" key, the thermal paper will advance. ■ Press and release the "↓ PAPER LCD" key, the thermal paper will retract.

APPENDIX A ITE Circuit Breaker model 14.4K Timing Chart

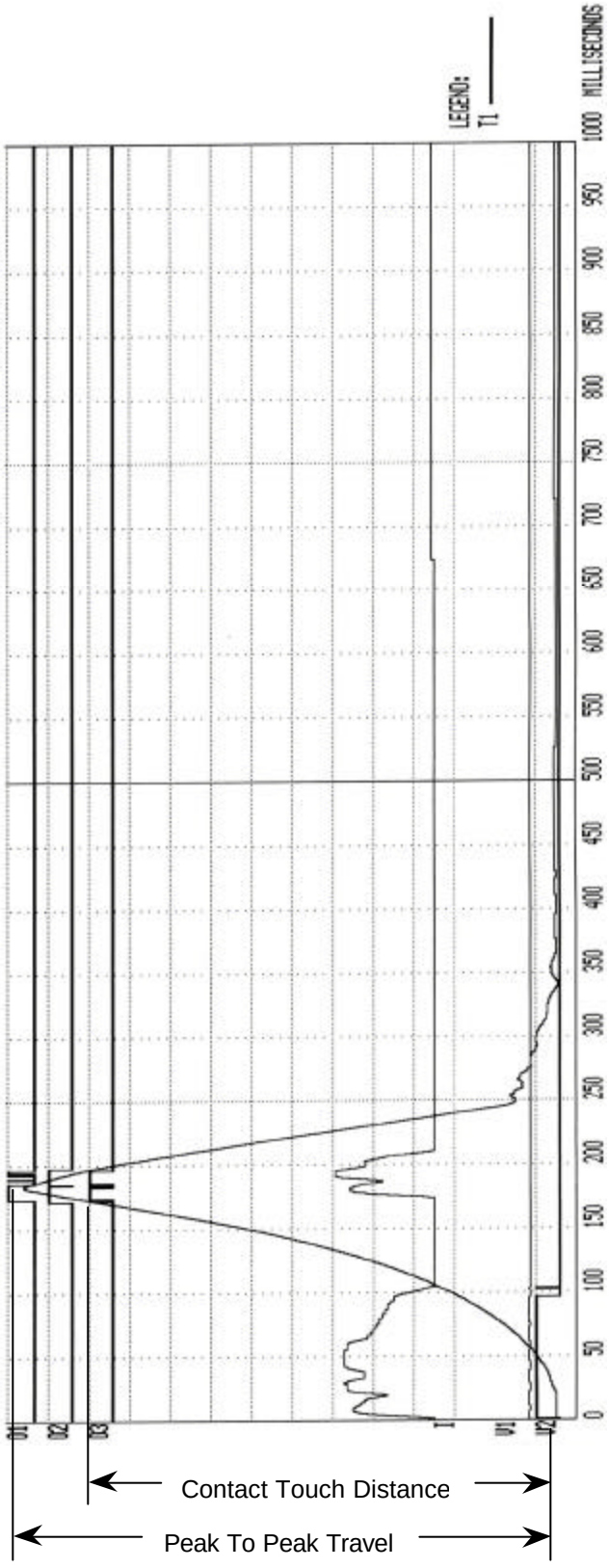


TYPICAL NO LOAD TRAVEL CURVES FOR OPENING AND CLOSING OPERATIONS
AT RATED CONTROL VOLTAGE



TYPICAL NO LOAD TRAVEL CURVES FOR RECLOSING AND TRIP-FREE OPERATIONS
AT RATED CONTROL VOLTAGE

APPENDIX B CLOSE-OPEN Timing Chart for ITE Circuit Breaker Model 14.4K



APPENDIX C CLOSE-OPEN Tabulated Report for ITE Circuit Breaker Model 14.4K

BREAKER TIMING RESULTS - 60 Hz

SHOT NUMBER: 0007
DATE: 09/01/03 TIME: 13:18:42

COMPANY: VANGUARD INSTRUMENT
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
OPERATOR:

TEST: CLOSE - OPEN

CONTACT CLOSE TIME

CH	TIME (mS)	CYCLES	BOUNCE (mS)
1	172.00	10.32	002.50
2	170.70	10.24	000.30
3	170.60	10.24	000.00

CONTACT OPEN TIME

CH	TIME (mS)	CYCLES	BOUNCE (mS)
1	185.00	11.10	013.40
2	196.70	11.80	000.10
3	000.00	00.00	196.20

CONTACT LIVE TIME

CH	TIME (mS)	CYCLES
1	013.00	00.78
2	026.00	01.56
3	000.00	00.00

PEAK TO PEAK TRAVEL (in)

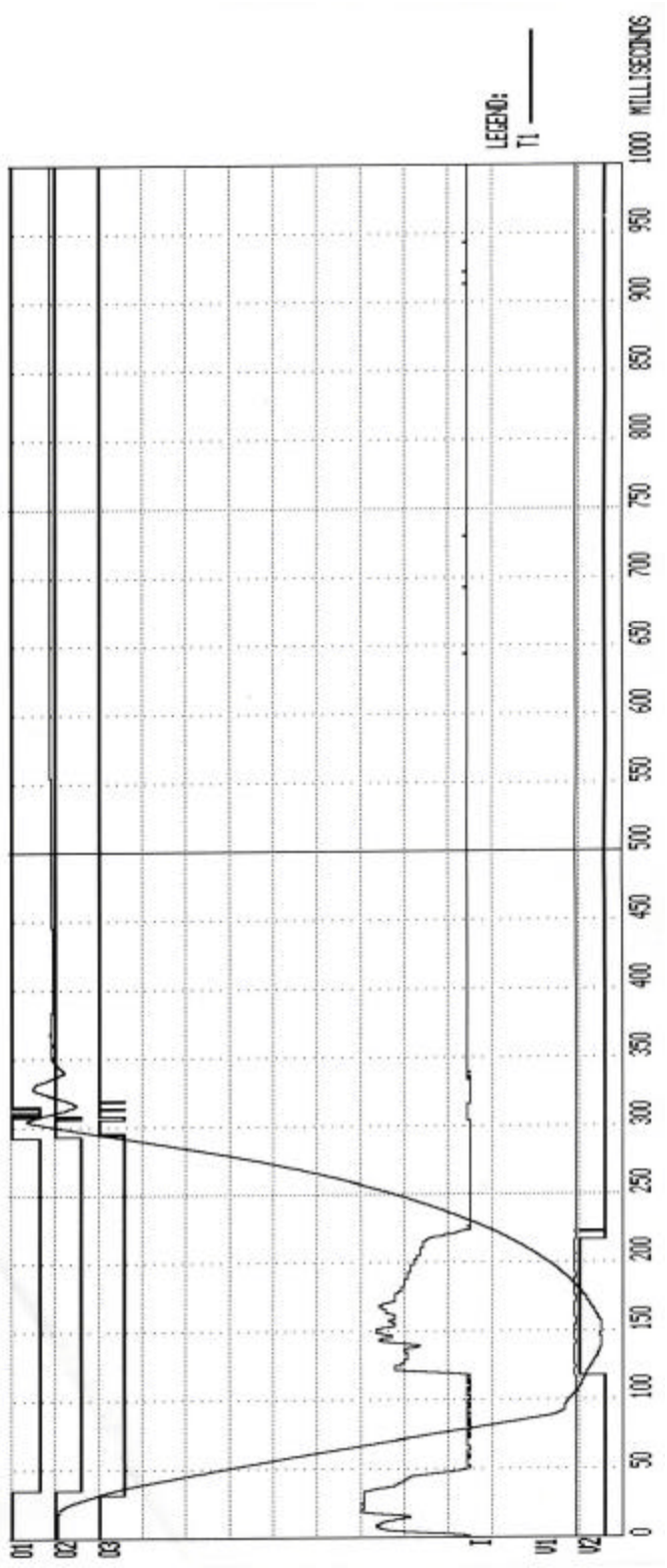
T1
07.44

CH1 TOUCH DISTANCE (in)
06.49

V1 NOMINAL VOLTAGE = 48 VOLTS
V1 MINIMUM VOLTAGE = 45 VOLTS
INITIATOR CURRENT = 05.6 AMPS

SHOT LENGTH: 1 SECOND
INSERTION RESISTOR: NO
TRIGGER: INTERNAL
DELAY: CLOSE CH #1

APPENDIX D OPEN-CLOSE Timing Chart for ITE Circuit Breaker Model 14.4K



APPENDIX E OPEN-CLOSE Tabulated Report for ITE Circuit Breaker Model 14.4K

BREAKER TIMING RESULTS - 60 Hz

SHOT NUMBER: 0008
DATE: 09/01/03 TIME: 13:20:37

COMPANY: VANGUARD INSTRUMENT
STATION:
CIRCUIT:
MFR:
MODEL:
S/N:
OPERATOR:

TEST: OPEN - CLOSE

CONTACT OPEN TIME

CH	TIME (mS)	CYCLES	BOUNCE (mS)
1	034.30	02.06	001.00
2	034.20	02.05	000.20
3	030.60	01.84	000.70

CONTACT RECLOSE TIME

CH	TIME (mS)	CYCLES	BOUNCE (mS)
1	291.10	17.47	023.50
2	292.30	17.54	015.60
3	292.80	17.57	025.80

CONTACT DEAD TIME

CH	TIME (mS)	CYCLES
1	256.80	15.41
2	258.10	15.49
3	262.20	15.73

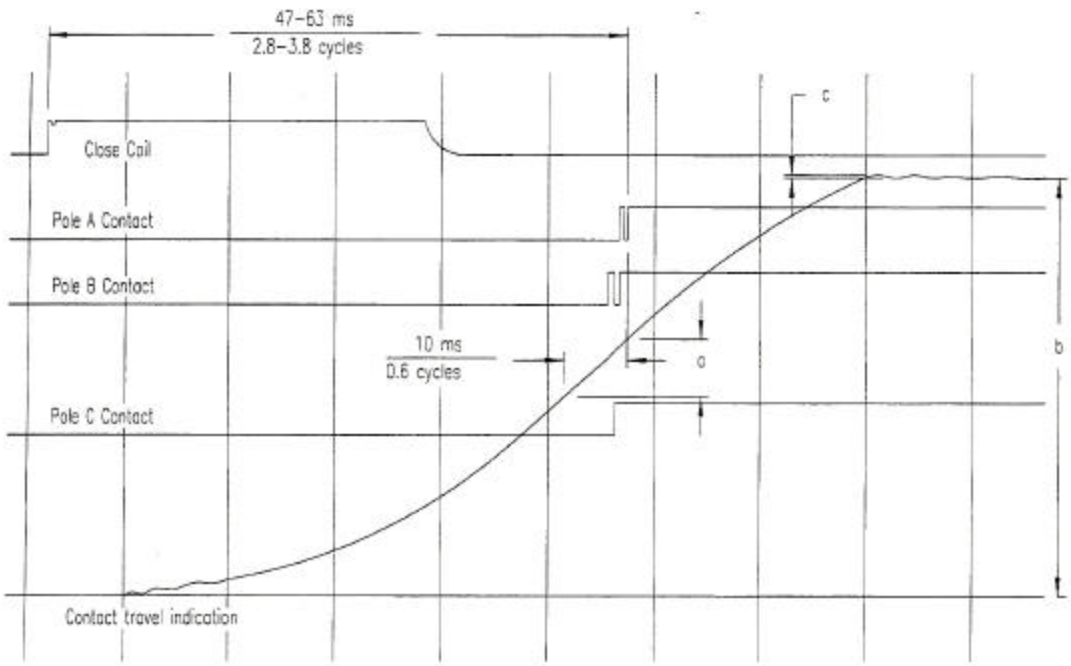
PEAK TO PEAK TRAVEL (in)

T1
07.21

V1 NOMINAL VOLTAGE = 48 VOLTS
V1 MINIMUM VOLTAGE = 47 VOLTS
INITIATOR CURRENT = 05.7 AMPS

SHOT LENGTH: 1 SECOND
INSERTION RESISTOR: NO
TRIGGER: INTERNAL
DELAY: 100 mS

APPENDIX F SIEMENS TCP Breaker Velocity Calculation



Example of Close Operation Record

Calculation For Contact Closing Velocity

V=12.0a/b meters/second

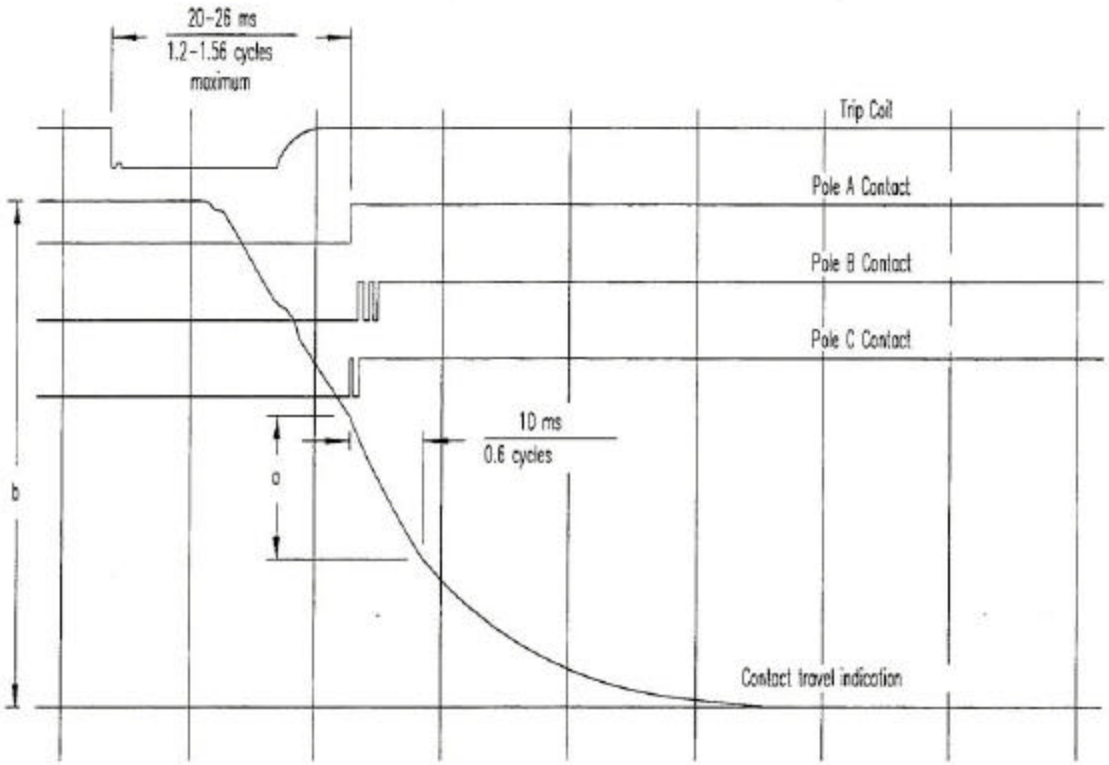
Calculation For Overtravel/rebound

S=120.0c/b millimeters

Note: a,b and c may be measured in any consistent units

Contact Stroke = 120 mm
Transducer Stroke = 80 mm

APPENDIX G SIEMENS SPS2 Breaker Velocity Calculation



Example of Opening Operation Record

Contact Stroke = 120mm
Transducer Stroke = 80 mm

Calculation For Contact Opening Velocity
V=12.0a/b meter/second

Note: a,b and may be measured in any consistant units

APPENDIX H CT-7000 SIEMENS SPS2 Test Plan

TEST PLAN NUMBER 1

MFR: SPS2 121
TYPE: Siemens
COMMENT:

CONTACT TIME PARAMETERS

	OPEN	CLOSE
MAX <mS>	026.0	063.0
MIN <mS>	020.0	047.0
DELTA LIM <mS>	004.0	004.0
C-O,O-C PARAMS:	LIVE	DEAD
MAX <mS>	040.0	200.0
MIN <mS>	020.0	150.0

RESISTOR ON-TIME PARAMETERS

	OPEN	CLOSE
MAX <mS>	000.0	000.0
MIN <mS>	000.0	000.0
DELTA LIM <mS>	000.0	000.0
C-O,O-C PARAMS:	LIVE	DEAD
MAX <mS>	000.0	000.0
MIN <mS>	000.0	000.0

TRAVEL PARAMETERS

	STRK mm	VEL M/S	O-TVL mm	BNC-BK mm
OPEN HI	085.1	04.90	003.0	003.0
OPEN LOW	074.9	04.20	000.0	000.0
CLOSE HI	085.1	04.50	004.1	004.1
CLOSE LO	074.9	03.50	000.0	000.0

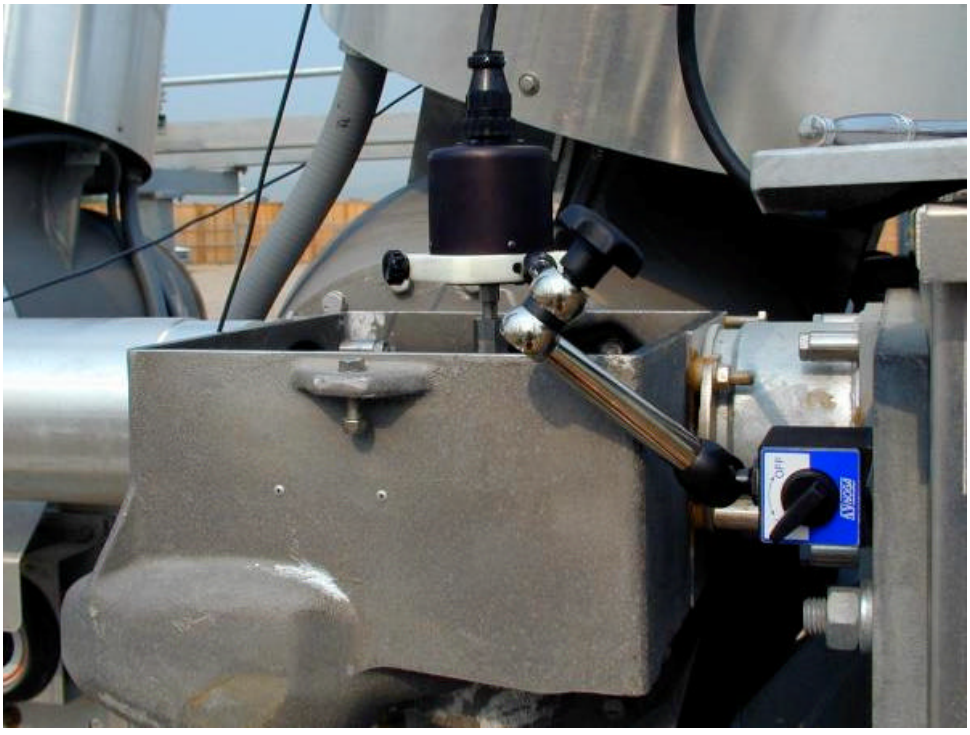
VEL = C×[DIST<AP1 - AP2>/STROKE]
C = 12.00 M/S

OPEN SPEED ANALYSIS POINTS:
POINT 1 = CONTACT
POINT 2 = CONTACT PLUS 010.0 mS

CLOSE SPEED ANALYSIS POINTS:
POINT 1 = CONTACT
POINT 2 = CONTACT MINUS 010.0 mS

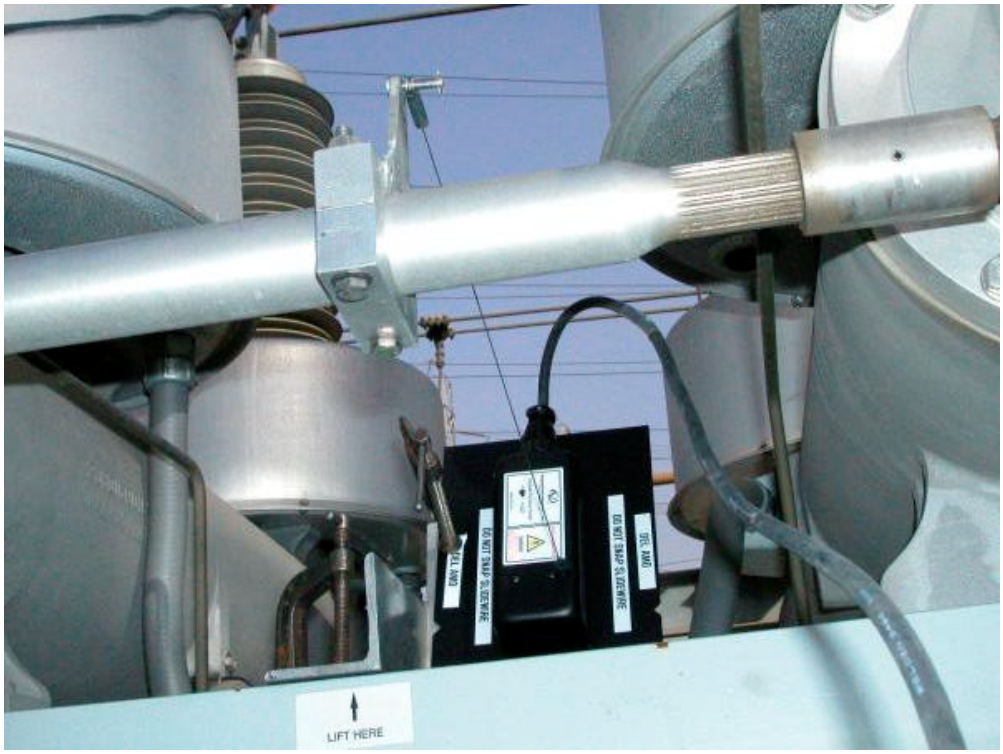
APPENDIX I CT-7000 Transducer Illustration

Linear Transducer on an OCB



Rotary Transducer on Alstom HE 1014 Circuit Breaker

Rotary Transducer on ABB HMB Mech



String Transducer on ABB 72PM Circuit Breaker

Vanguard Instruments
Company, Inc.

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